

**LIDAR REMOTE SENSING DATA COLLECTION  
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES  
WILLAMETTE VALLEY PHASE I, OREGON**

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# LIDAR REMOTE SENSING DATA COLLECTION:

## DOGAMI, WILLAMETTE VALLEY PHASE I STUDY AREA

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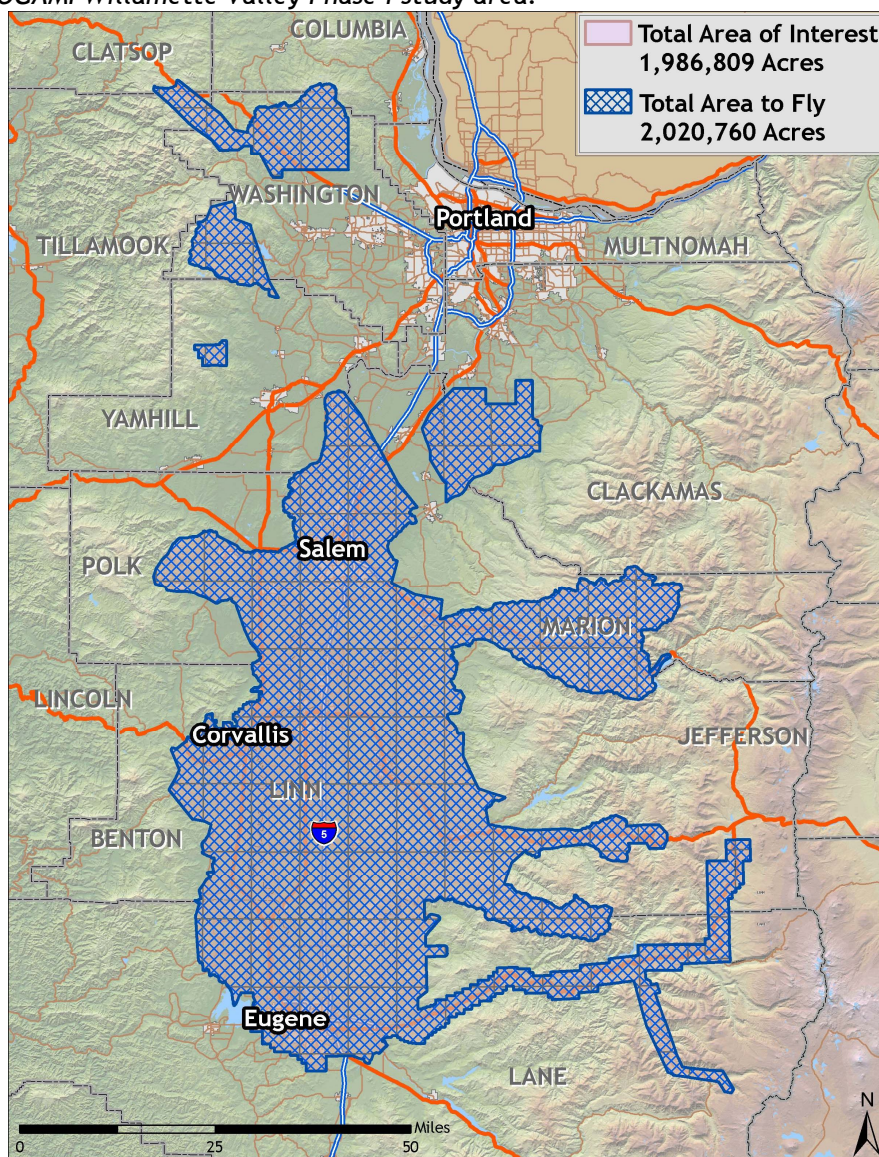


# 1. Overview

## 1.1 Study Area (Willamette Valley Phase I)

Watershed Sciences, Inc. has collected Light Detection and Ranging (LiDAR) data of the Willamette Valley Phase I study area for the Oregon Department of Geology and Mineral Industries (DOGAMI). The complete area of interest (AOI) totals 3,104 square miles (1,986,809 acres) and the total area flown (TAF) covers 3,157 square miles (2,020,760 acres). The TAF acreage is greater than the original AOI acreage due to buffering and flight planning optimization (**Figure 1.1** below). DOGAMI data are delivered in OGIC(HARN): Projection: Oregon Statewide Lambert Conformal Conic; horizontal and vertical datums: NAD83 (HARN)/NAVD88(Geoid03); Units: International Feet.

**Figure 1.1.** DOGAMI Willamette Valley Phase I study area.



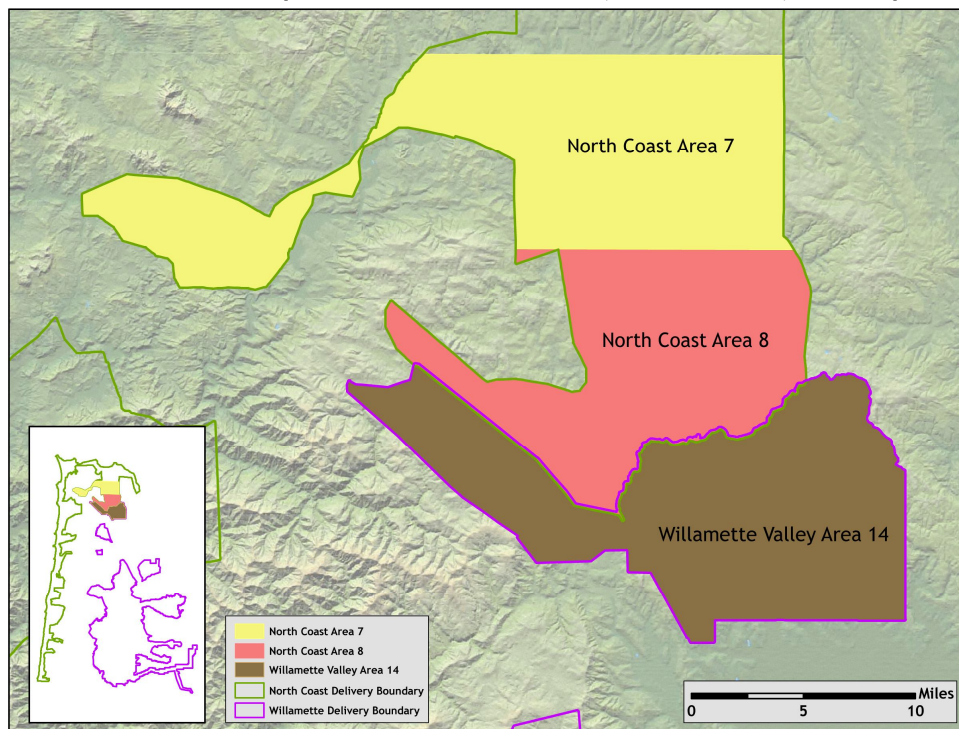


## 1.2 Area Delivered to Date

Total delivered acreage is detailed below.

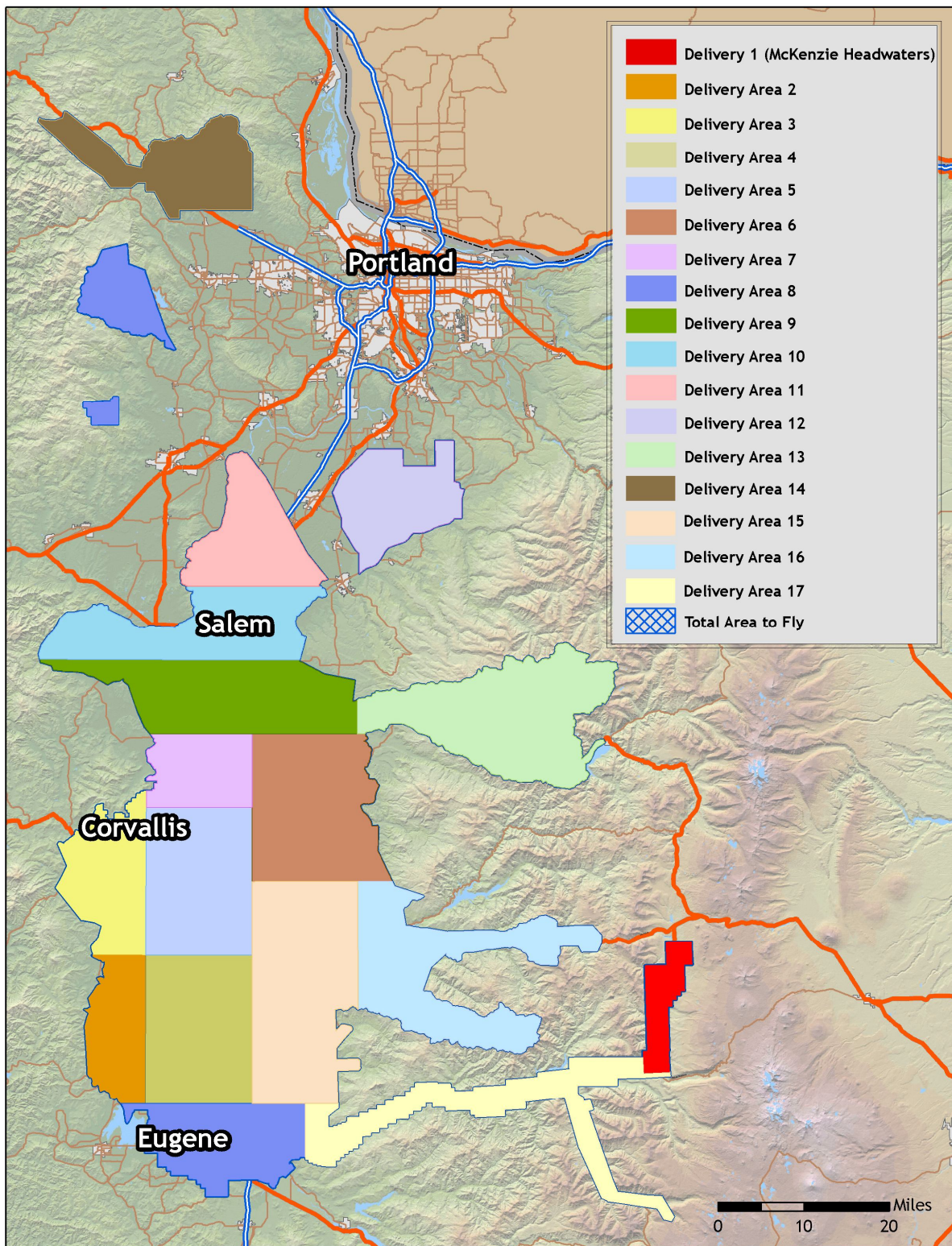
DOGAMI Willamette Valley Phase I				
	Delivery Date	Acquisition Date	AOI Acres	TAF Acres
Delivery Area 1*	January 16, 2009	Oct. 22 - Oct. 24, 2008	30,472	32,150
Delivery Area 2	April 29, 2009	Aug. 31, 2008 - Feb. 22, 2009	66,377	67,377
Delivery Area 3	April 29, 2009	Aug. 31 - Sept. 14, 2008	88,466	89,974
Delivery Area 4	May 18, 2009	Aug. 31, 2008 - Feb. 22, 2009	136,997	136,997
Delivery Area 5	May 18, 2009	Aug. 31 - Sept. 14, 2008	136,424	136,424
Delivery Area 6	May 29, 2009	Aug. 31 - Sept. 21, 2008	157,008	157,904
Delivery Area 7	May 29, 2009	Aug. 31 - Sept. 21, 2008	64,771	65,249
Delivery Area 8	June 19, 2009	Aug. 31, 2008 - Apr. 5, 2009	151,639	155,491
Delivery Area 9	July 2, 2009	Sept. 14, 2008 - Mar. 3, 2009	146,621	147,742
Delivery Area 10	July 17, 2009	Oct. 5, 2008 - Mar. 15, 2009	123,871	125,480
Delivery Area 11	July 17, 2009	Oct. 5, 2008 - Nov. 11, 2008	88,153	89,804
Delivery Area 12	July 23, 2009	Sept. 28, 2008 - Mar. 15, 2009	86,943	89,161
Delivery Area 13	September 18, 2009	Sept. 17, 2008 - Jul. 01, 2009	173,501	177,375
Delivery Area 14	November 17, 2009	May 18, 2009 - Jun. 16, 2009	92,998	96,010
Delivery Area 15	December 21, 2009	Oct. 10, 2008 - Jun. 7, 2009	190,734	191,635
Delivery Area 16	December 21, 2009	Sept. 7, 2008 - Jun. 27, 2009	146,581	151,037
Delivery Area 17	December 21, 2009	Oct. 19, 2009 - Jun. 9, 2009	105,253	110,950
Total Acres			1,986,809	2,020,760

*\*Delivery area 14 adjoins north coast areas 7 and 8 (see image below). All stats for Willamette Valley Phase 1 area 14 will be reported in the north coast, area 7 and 8, data report.*





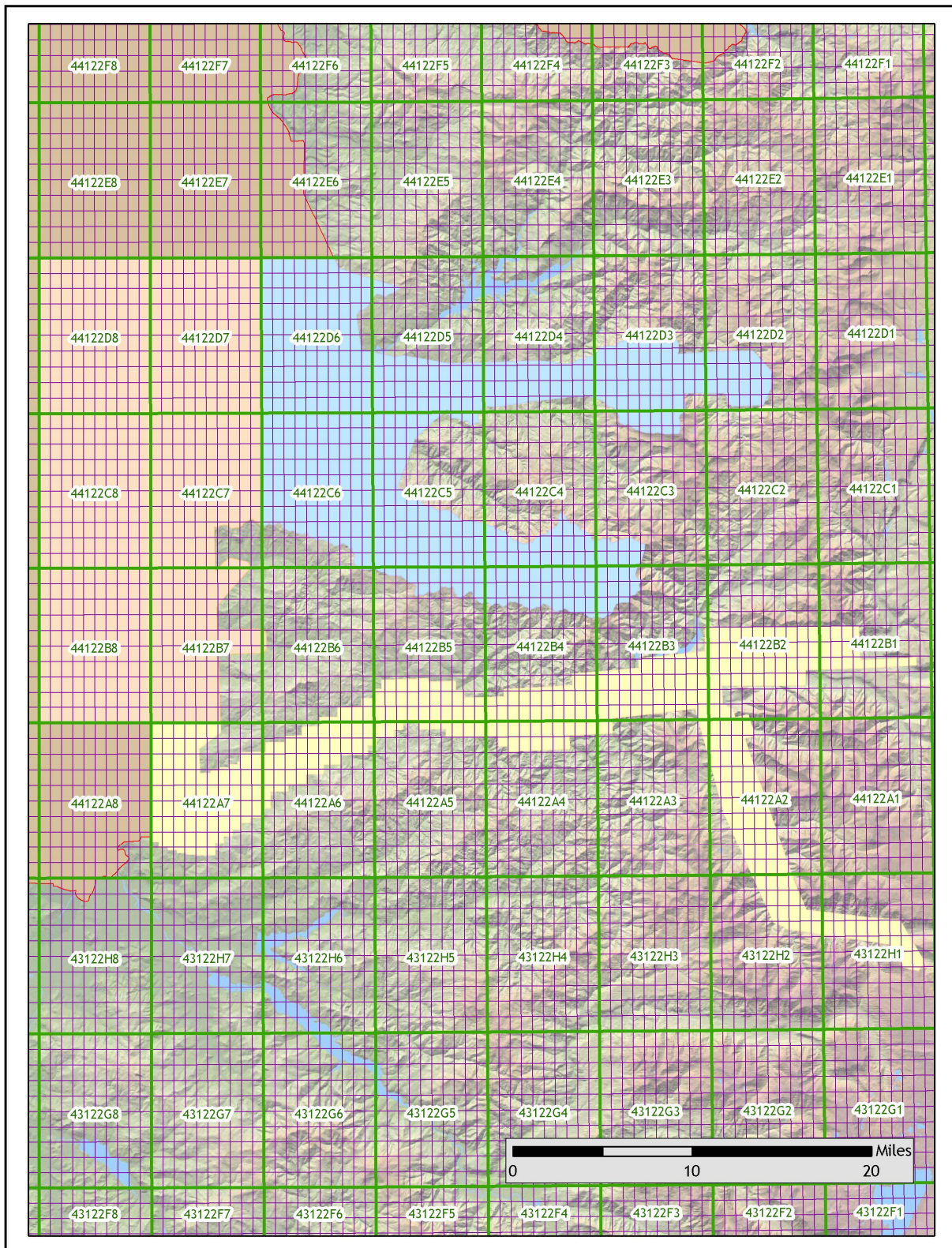
**Figure 1.2.** Willamette Valley Phase I study area, illustrating the delivered acres.



\*The data report for delivery area 1 was listed as the McKenzie Headwaters study area and delivered separately.



**Figure 1.3. Willamette Valley Phase I study area, illustrating the delivered 0.75 and 7.5 minute USGS quads.**





### 1.3 Acquisition and Ground Survey

LiDAR acquisition for delivery areas 2 through 17 occurred from August 31, 2008 - July 1, 2009 for the Willamette Valley Phase I study area.

**Figure 1.4.** Actual flightlines for the Willamette Valley Phase I study area illustrating the dates flown (based on GPS week).

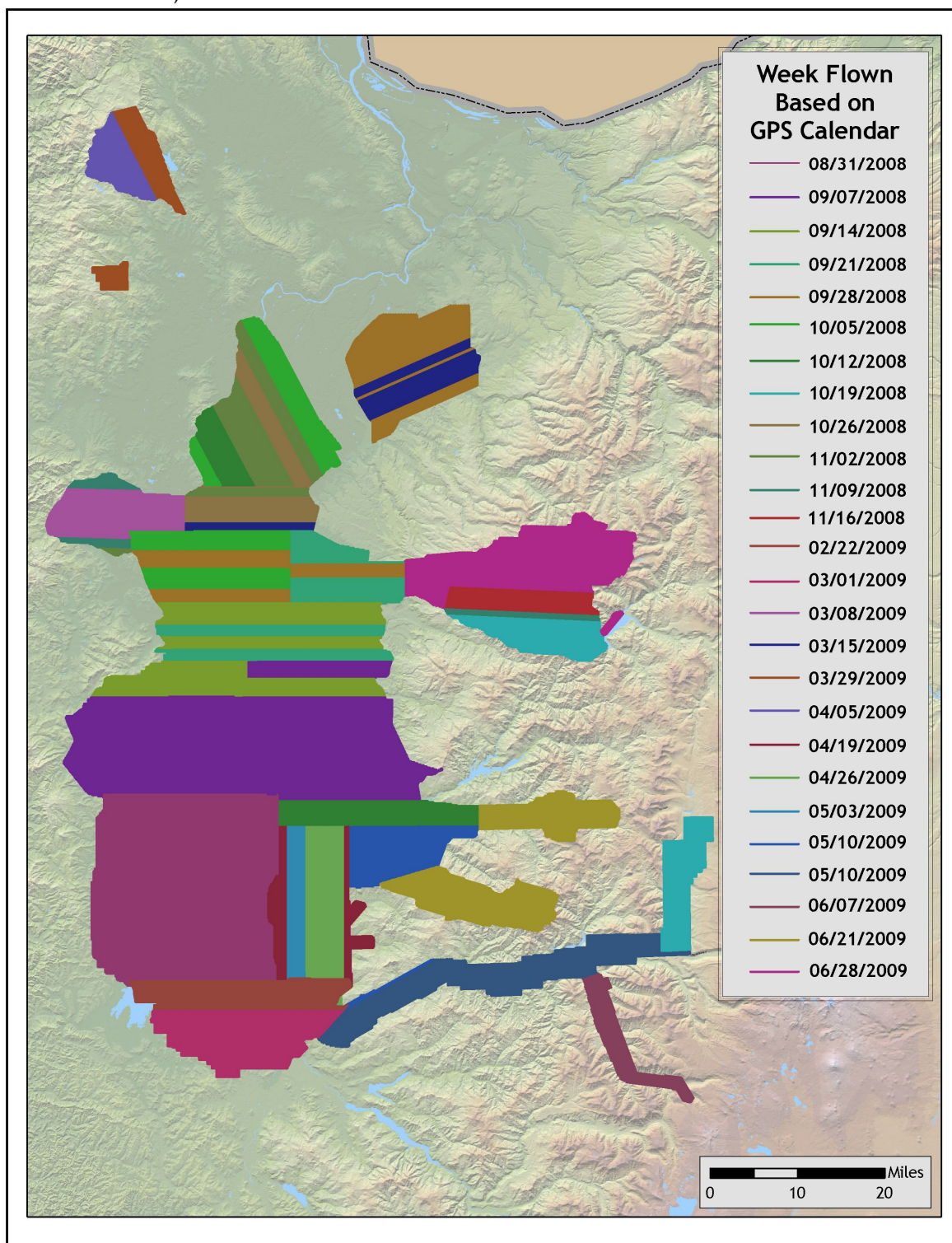
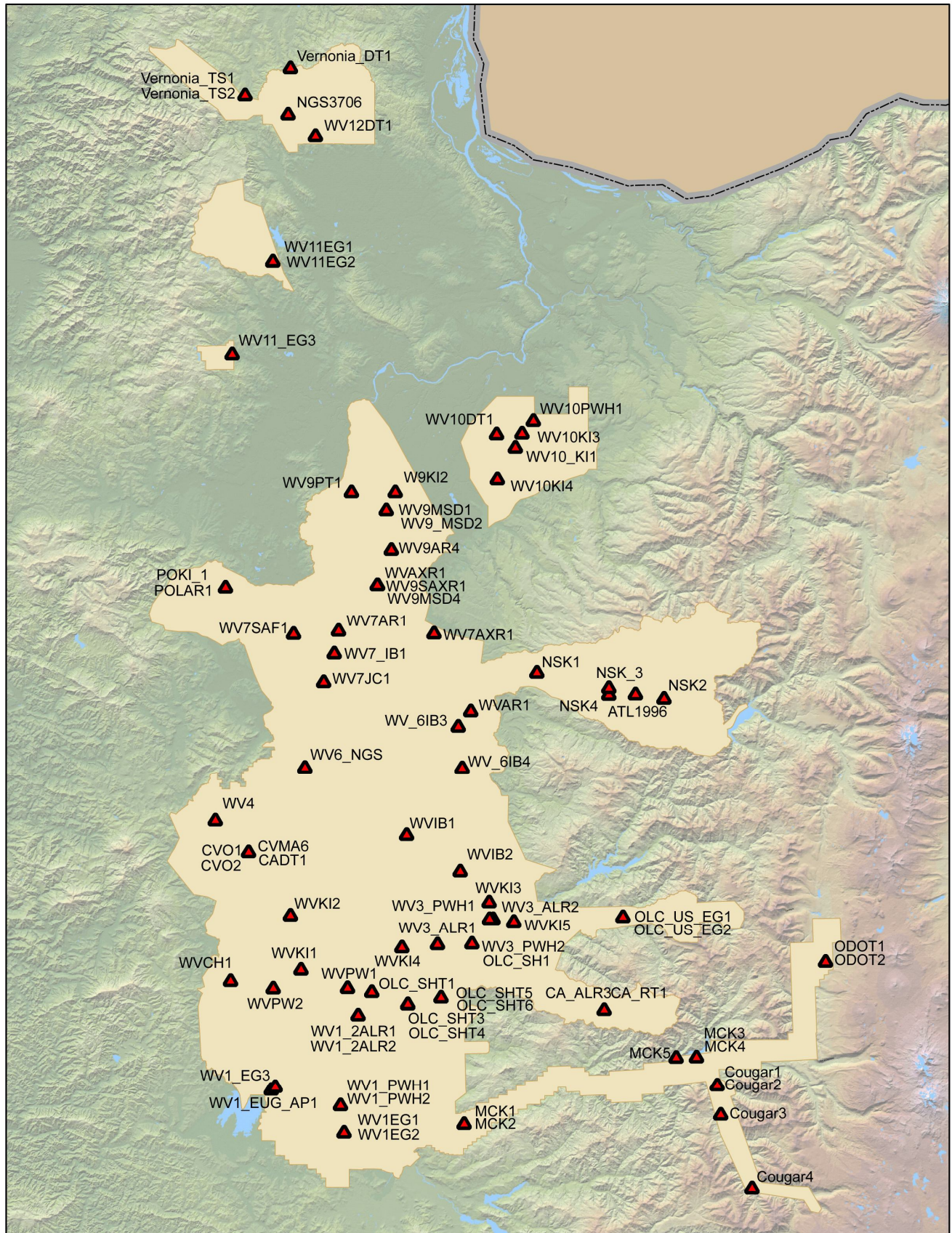




Figure 1.5. Base stations for the Willamette Valley Phase I study area.



**Table 1.1.** Base Station Surveyed Coordinates, (NAD83/NAVD88, OPUS corrected) used for kinematic post-processing of the aircraft GPS data for the Willamette Valley Phase I study area.

Base Stations ID	Datum NAD83 (HARN)		GRS80
	Latitude (North)	Longitude (West)	Ellipsoid Height (m)
ATL1996	44 45 19.98896	122 24 51.99551	266.8315
CA_ALR3	44 15 03.43854	122 29 22.60285	721.158
CA_RT1	44 15 03.37714	122 29 22.51820	721.141
CADT1	44 30 15.57786	123 16 52.94455	51.793
Cougar1	44 07 43.14100	122 14 20.83625	499.0855
Cougar2	44 07 43.16557	122 14 20.79015	499.069
Cougar3	44 04 55.76091	122 13 54.72786	500.908
Cougar4	43 57 50.07868	122 9 52.01273	1004.166
CVMA6	44 30 16.46154	123 16 53.14095	51.867
CVMAG2	44 30 15.85789	123 16 53.25330	51.829
CVO1	44 30 16.46159	123 16 53.14113	51.858
CVO2	44 30 15.85796	123 16 53.25332	51.825
MCK1	44 04 08.77680	122 48 06.60033	161.664
MCK2	44 04 08.79505	122 48 6.51738	161.6255
MCK3	44 10 27.21440	122 17 4.97476	393.5735
MCK4	44 10 27.25402	122 17 5.09315	393.571
MCK5	44 10 26.38017	122 19 49.34571	394.1665
NGS3706	45 41 00.77641	123 11 48.80841	58.01
NSK_3	44 45 56.88759	122 28 28.54717	387.869
NSK1	44 47 27.05807	122 38 09.58269	163.614
NSK2	44 44 53.11490	122 21 02.96038	443.5455
NSK4	44 45 18.59839	122 28 28.00832	239.4585
ODOT1	44 19 28.97985	121 59 42.83307	865.68
ODOT2	44 19 28.99768	121 59 42.74919	865.858
OLC_SH1	44 21 29.57903	122 46 57.69388	185.6155
OLC_SHT1	44 16 51.99567	123 00 23.72990	95.165
OLC_SHT3	44 15 39.97524	122 55 34.56131	660.818
OLC_SHT4	44 15 40.10459	122 55 34.61008	660.668
OLC_SHT5	44 16 18.57738	122 51 06.55677	419.02
OLC_SHT6	44 16 18.54142	122 51 06.49556	419.052
OLC_US_EG1	44 23 59.49172	122 26 44.45414	260.224
OLC_US_EG2	44 23 59.39993	122 26 44.42557	260.094
POKI_1	44 55 38.66110	123 20 07.38243	88.969
POLAR1	44 55 38.80490	123 20 07.11584	88.7995
Vernonia_DT1	45 45 27.55697	123 11 31.15795	270.445
Vernonia_TS1	45 42 51.50971	123 17 43.86203	323.289

(Table 1.1 continued on next page)



(Table 1.1 continued from previous page)

**Table 1.1.** Base Station Surveyed Coordinates, (NAD83/NAVD88, OPUS corrected) used for kinematic post-processing of the aircraft GPS data for the Willamette Valley Phase I study area.

Base Stations ID	Datum NAD83 (HARN)		GRS80
	Latitude (North)	Longitude (West)	Ellipsoid Height (m)
Vernonia_TS2	45 42 51.45486	123 17 43.77242	323.323
W9KI2	45 04 47.45357	122 57 12.95446	32.1235
WV_6IB3	44 42 20.47071	122 48 46.07149	84.765
WV_6IB4	44 38 20.91651	121 48 13.88306	88.254
WV1_2ALR1	44 14 36.45653	123 02 11.12672	81.005
WV1_2ALR2	44 14 36.55739	123 02 11.34727	81.014
WV1_EG3	44 07 26.69109	123 13 47.27702	86.9345
WV1_EUG_AP1	44 07 43.07971	123 13 14.42012	86.614
WV1_PWH1	44 05 57.01460	123 04 31.39832	102.557
WV1_PWH2	44 05 57.06332	123 04 31.40301	102.522
WV10_KI1	45 09 03.09445	122 40 54.82179	42.712
WV10_KI2	45 09 03.06309	122 40 55.13837	42.714
WV10DT1	45 10 21.41315	122 43 26.30645	32.3135
WV10KI3	45 10 24.88975	122 39 59.50283	49.843
WV10KI4	45 5 59.95580	122 43 21.11231	44.427
WV10PWH1	45 11 37.03389	122 38 26.38199	51.351
WV11_EG3	45 17 56.90350	123 19 22.02585	117.419
WV11EG1	45 26 52.94610	123 13 52.53149	52.164
WV11EG2	45 26 53.12241	123 13 52.49865	52.2235
WV12DT1	45 38 56.98416	123 08 04.69567	44.2085
WV1EG1	44 03 20.01625	123 4 2.53405	105.251
WV1EG2	44 03 20.18440	123 4 2.75328	105.148
WV3_ALR1	44 21 25.46560	122 51 36.25289	116.501
WV3_ALR2	44 23 51.55262	122 44 37.60358	148.192
WV3_PWH1	44 23 50.39412	122 44 08.46323	138.708
WV3_PWH2	44 21 29.51252	122 46 57.71022	185.558
WV4	44 33 17.09016	123 21 21.76005	81.679
WV6_NGS	44 38 23.26248	123 09 22.19571	43.629
WV7_IB1	44 49 19.41580	123 05 25.72185	52.3175
WV7AR1	44 51 29.95230	123 04 52.60626	158.014
WV7AXR1	44 51 13.15065	122 51 59.69020	91.498

(Table 1.1 continued on next page)

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**Table 1.1.** Base Station Surveyed Coordinates, (NAD83/NAVD88, OPUS corrected) used for kinematic post-processing of the aircraft GPS data for the Willamette Valley Phase I study area.

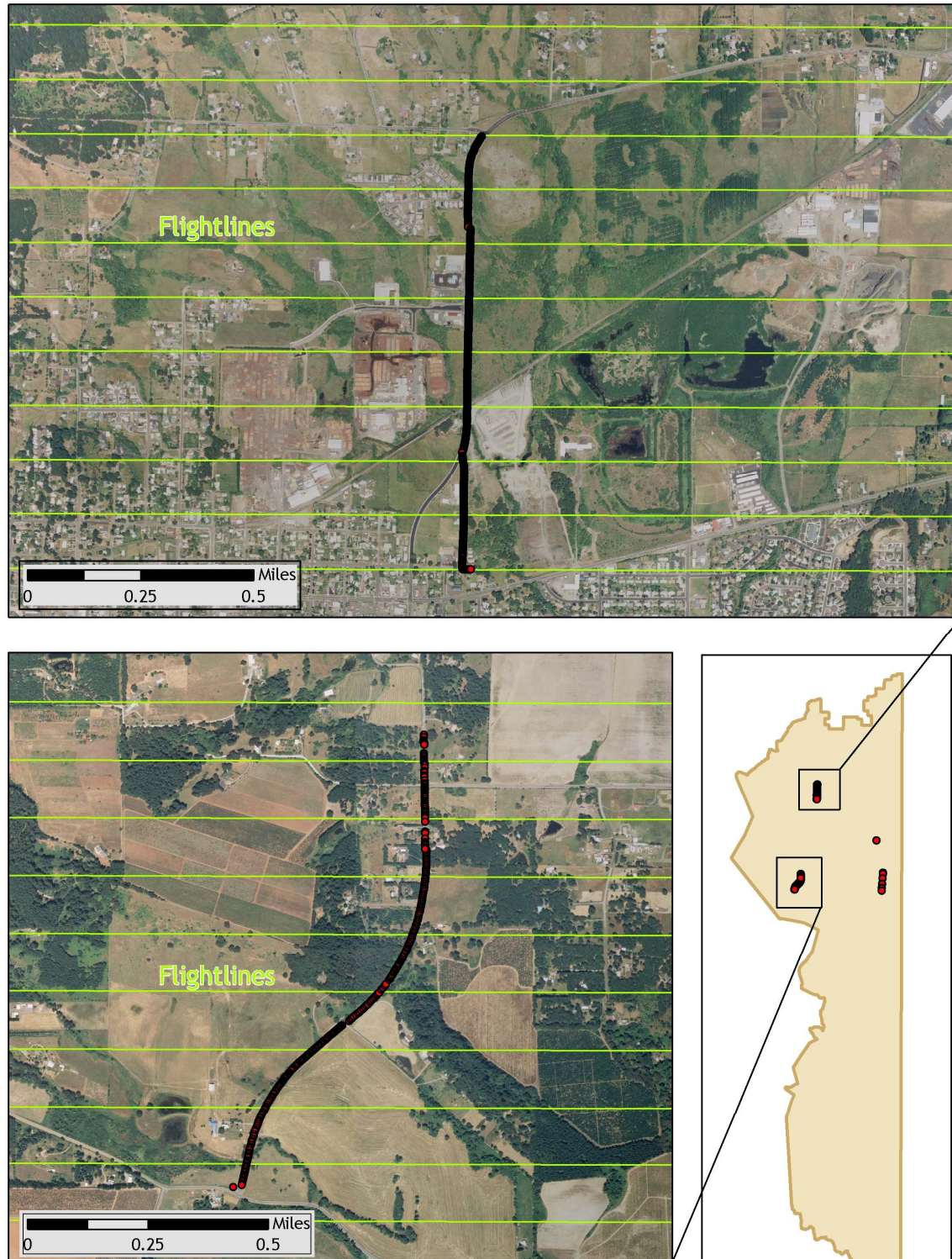
Base Stations ID	Datum NAD83 (HARN)		GRS80
	Latitude (North)	Longitude (West)	Ellipsoid Height (m)
WV7JC1	44 46 34.37419	123 06 52.58730	31.406
WV7SAF1	44 51 10.56684	123 10 54.74948	22.448
WV9_MSD2	45 03 2.15144	122 58 24.20333	33.38
WV9AR4	44 59 16.29804	122 57 42.58599	33.599
WV9MSD1	45 03 02.06370	122 58 24.26463	33.342
WV9MSD4	44 55 54.05524	122 59 36.96889	37.1705
WV9PT1	45 4 46.51945	123 3 7.74202	11.118
WV9SAXR1	44 55 53.93185	122 59 35.68529	37.318
WVAR1	44 43 48.10903	122 47 2.71423	221.035
WVAXR1	44 55 54.07364	122 59 36.83714	37.1935
WVCH1	44 17 52.00532	123 19 13.83016	92.247
WVIB1	44 31 55.68533	122 55 41.88412	82.45
WVIB2	44 28 27.17988	122 48 32.92656	118.736
WVKI1	44 18 59.69538	123 9 49.49224	67.228
WVKI2	44 24 11.82167	123 11 14.29976	60.707
WVKI3	44 25 27.33838	122 44 40.44620	154.313
WVKI4	44 21 07.03049	122 56 20.70236	96.654
WVKI5	44 23 34.26744	122 41 23.87745	180.302
WVPW1	44 17 14.12051	123 03 36.07969	74.103
WVPW2	44 17 10.74383	123 13 33.86193	66.538



RTK for the delivery area 14 is reported in the north coast, delivery areas 7 and 8, report.

For data delivery areas 2 - 13 and 15 - 17, a total of 38,371 RTK points were collected in the study area. Figures 1.6 - 1.14 show a detailed view of selected RTK locations per delivery.

**Figure 1.6.** RTK point locations in the study area for delivery areas 2 and 3; images are NAIP orthoimages.





**Figure 1.7.** RTK point locations in the study area for delivery areas 4 and 5; images are NAIP orthoimages.





**Figure 1.8.** RTK point locations in the study area for delivery areas 6 and 7; images are NAIP orthoimages.

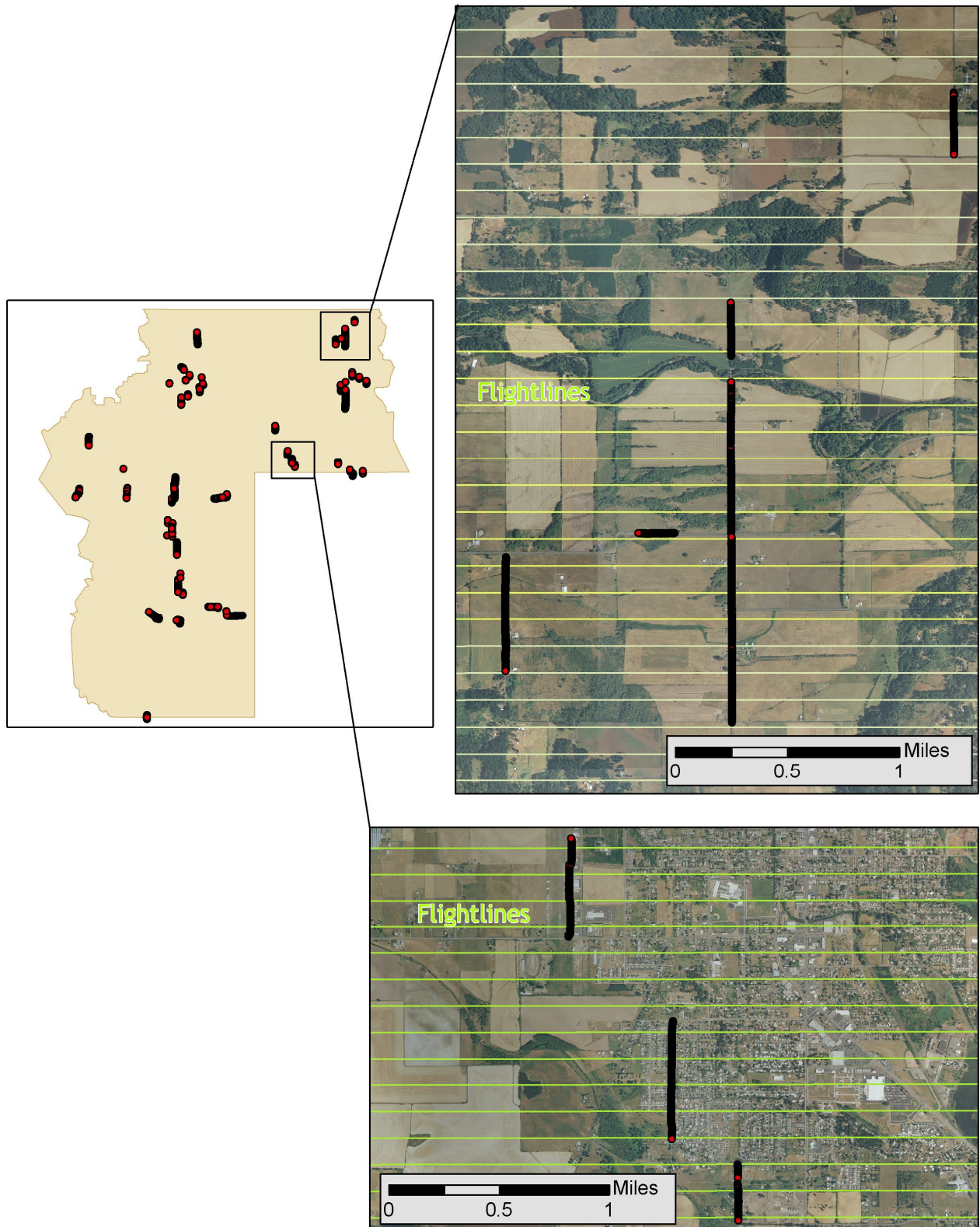




Figure 1.9. RTK point locations in the study area for delivery area 8; images are NAIP orthoimages.

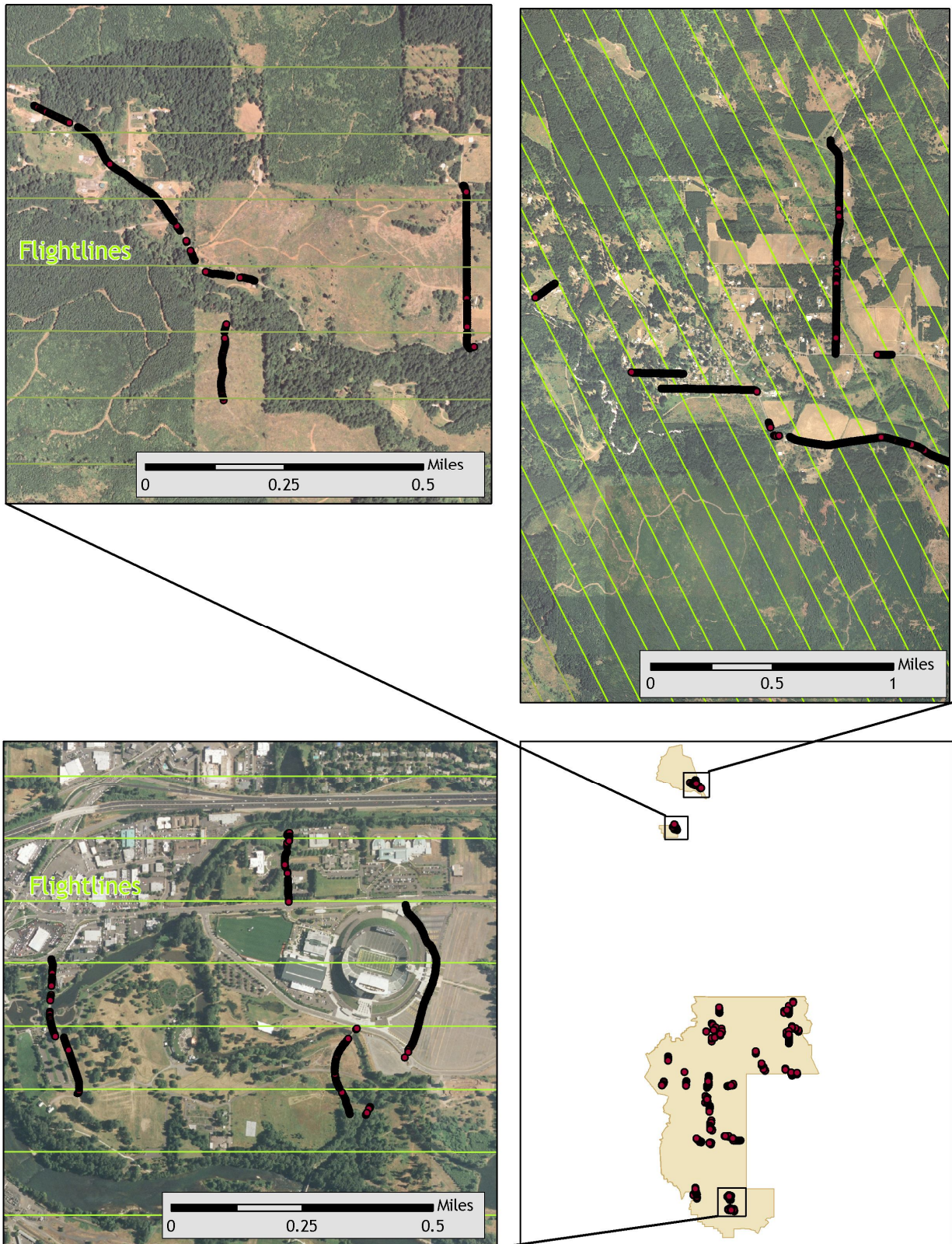
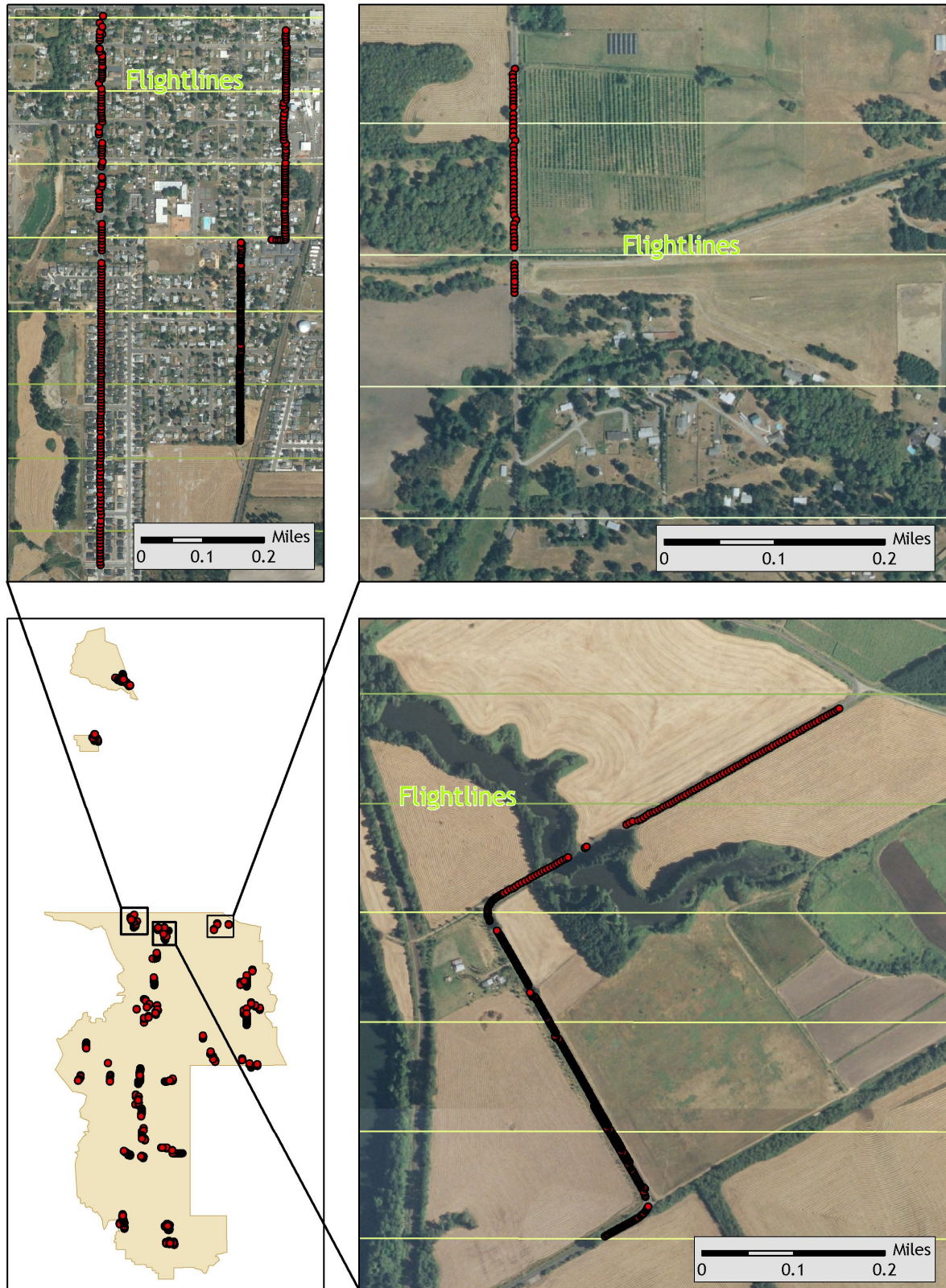




Figure 1.10. RTK point locations in the study area for delivery area 9; images are NAIP orthoimages.





**Figure 1.11.** RTK point locations in the study area for delivery areas 10 and 11; images are NAIP orthoimages.

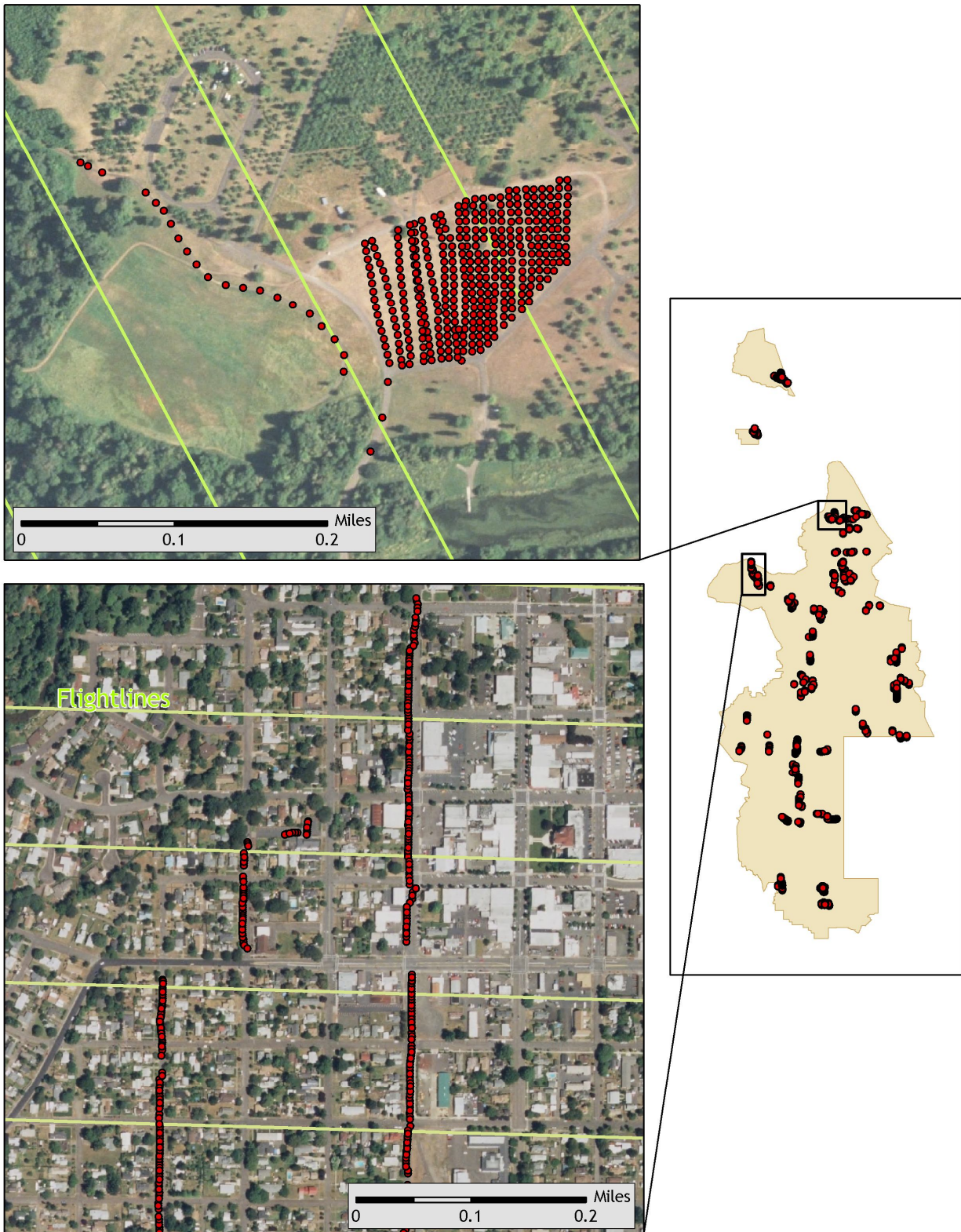




Figure 1.12. RTK point locations in the study area for delivery area 12; images are NAIP orthoimages.

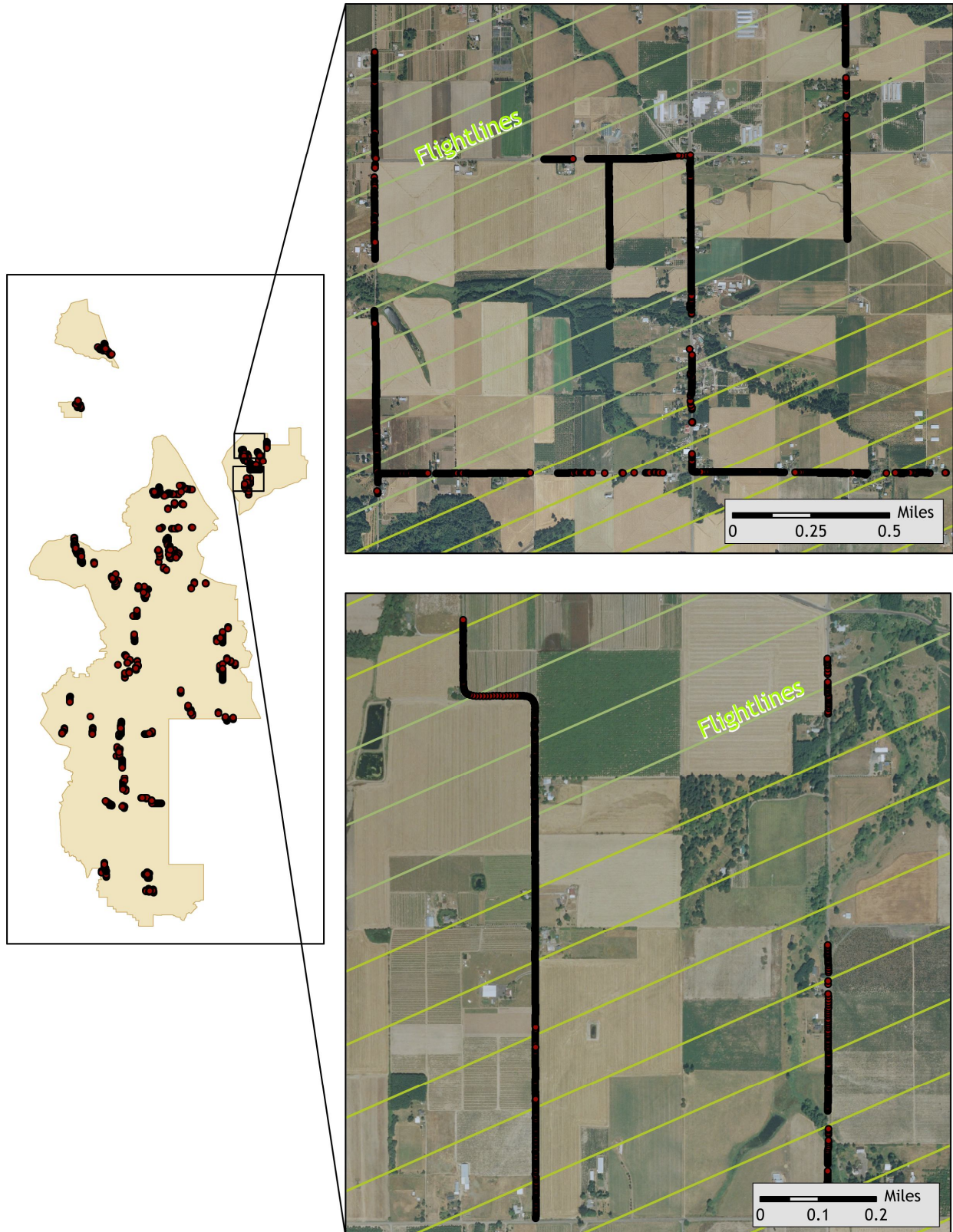
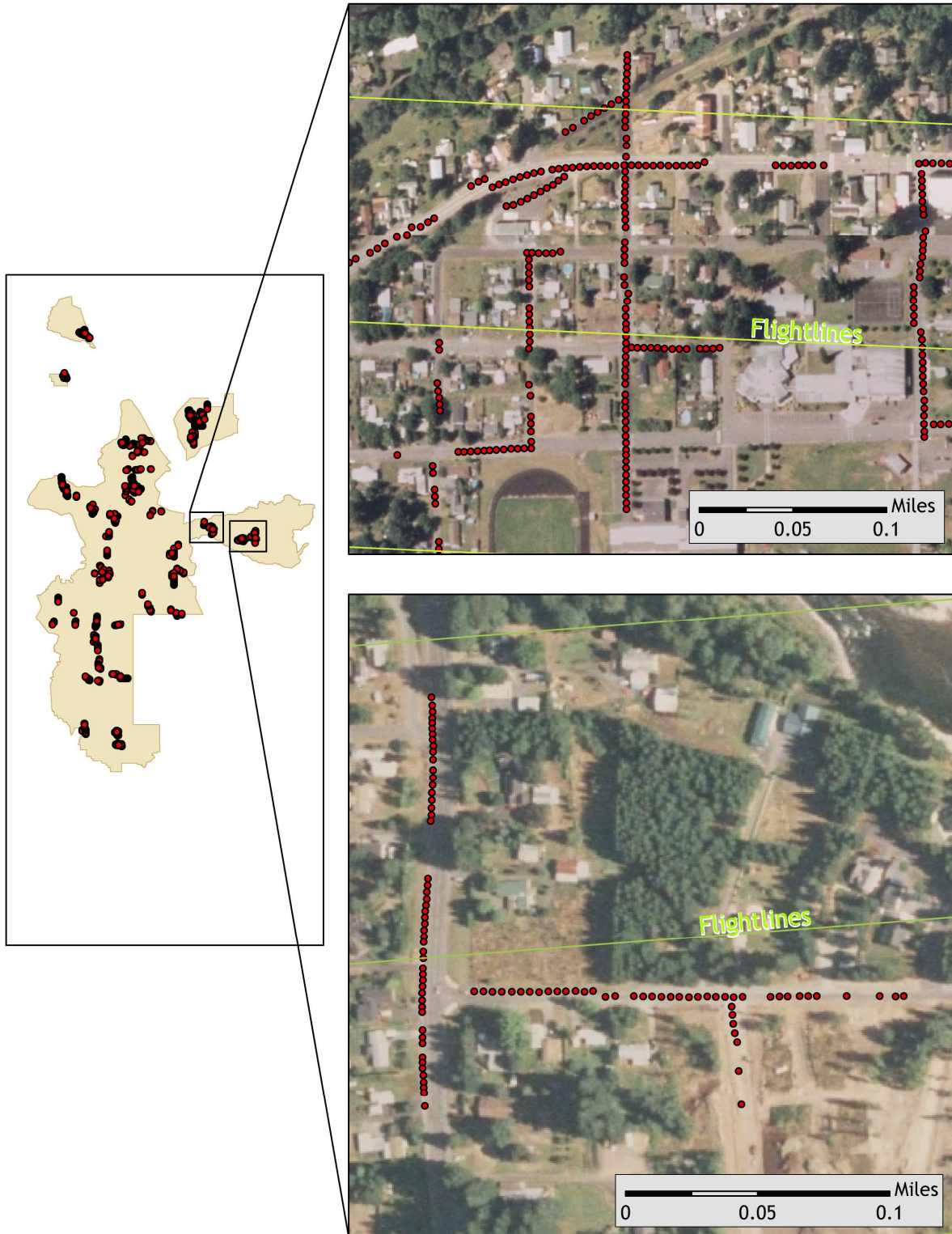
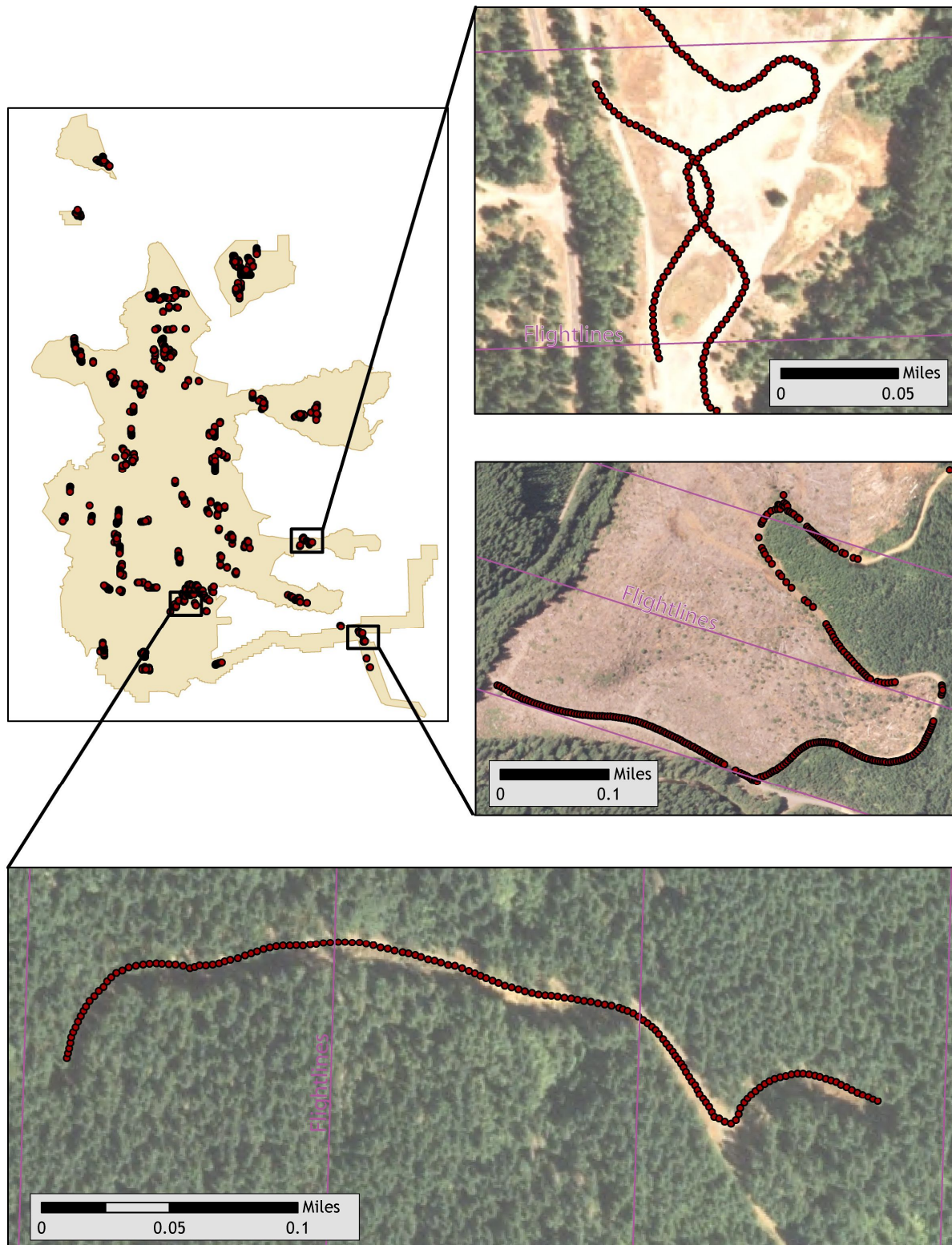


Figure 1.13. RTK point locations in the study area for delivery area 13; images are NAIP orthoimages.





**Figure 1.14.** RTK point locations in the study area for delivery areas 15, 16, and 17; images are NAIP orthoimages.



## 2. Accuracy

### 2.1 Relative Accuracy

#### Relative Accuracy Calibration Results

Relative accuracy calibration statistics for delivery area 14 were reported in the north coast, delivery areas 7 and 8, data report.

Relative accuracy statistics are based on the comparison of 2165 flightlines and over 33 billion points. Relative accuracy is reported for the portion of the study area listed in Figure 2.1 below.

- Project Average = 0.163 ft (0.050 m)
- Median Relative Accuracy = 0.136 ft (0.042 m)
- 1 $\sigma$  Relative Accuracy = 0.173 ft (0.053 m)
- 2 $\sigma$  Relative Accuracy = 0.327 ft (0.100 m)

**Figure 2.1.** *Relative Accuracy Covered Area*

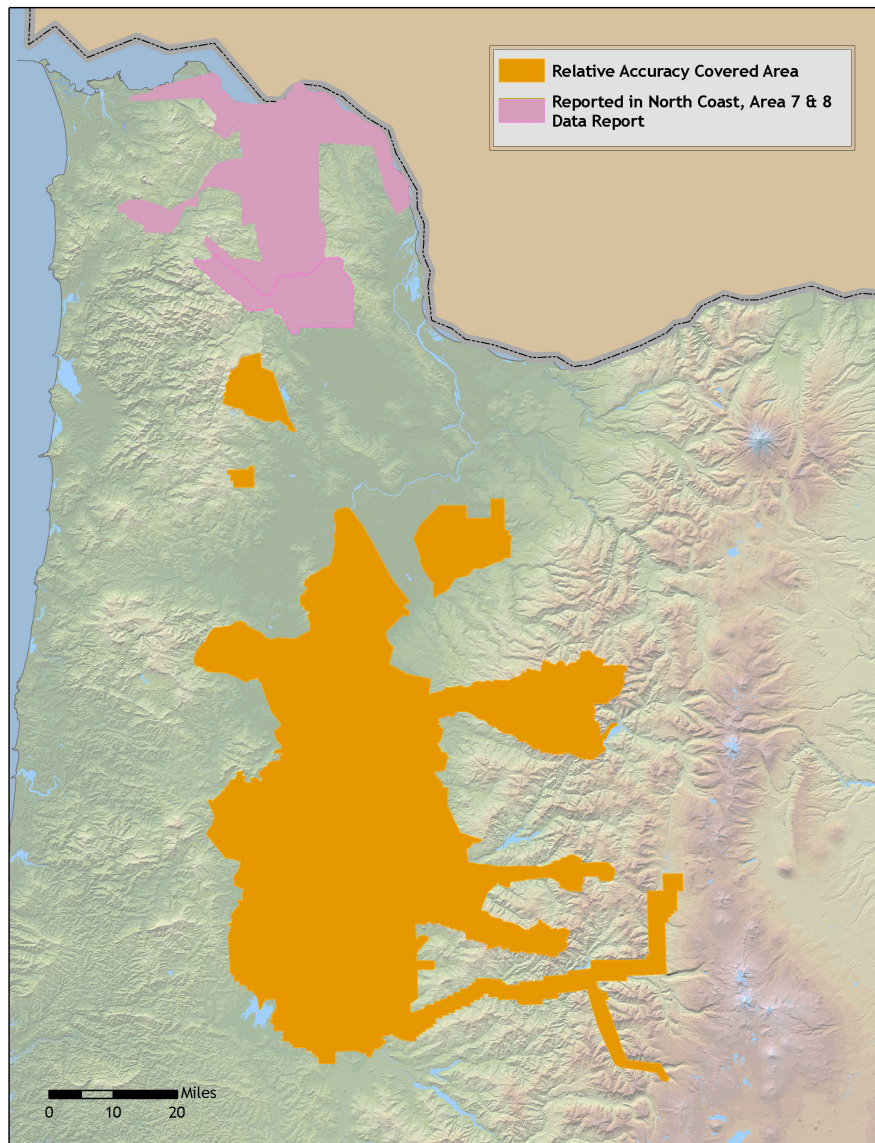




Figure 2.2. Statistical relative accuracies, non slope-adjusted.

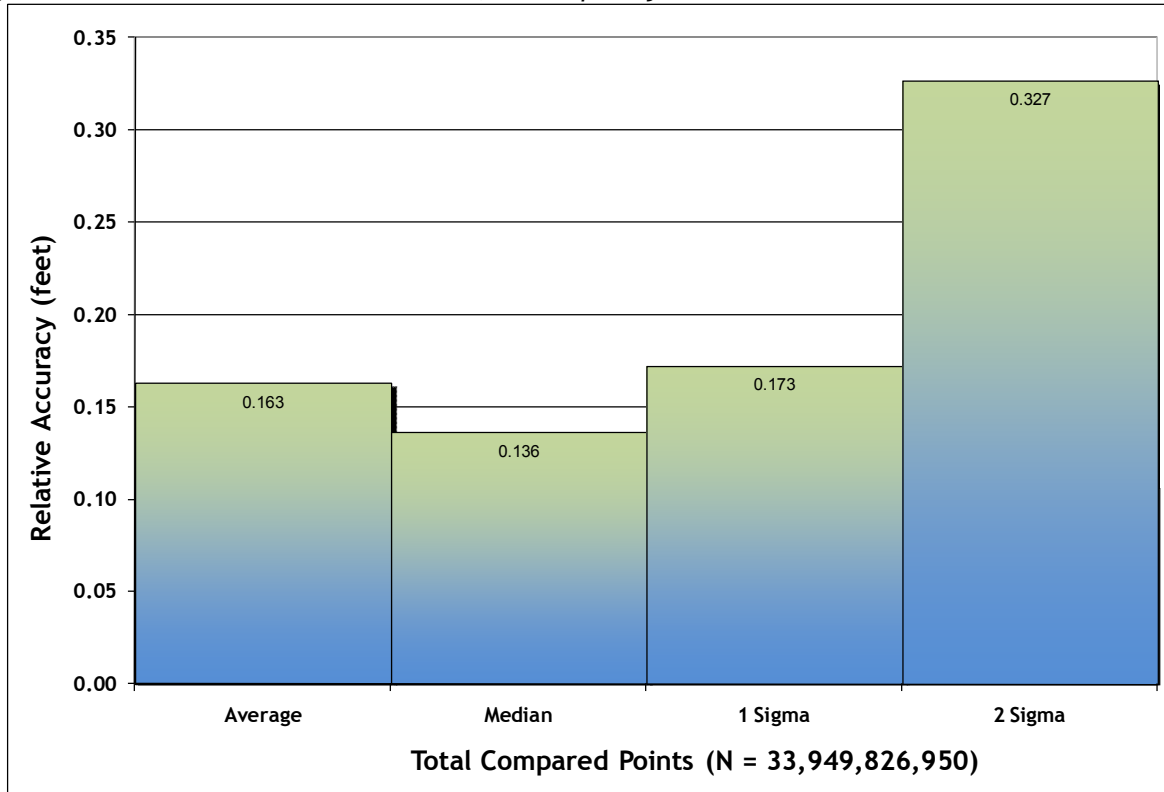
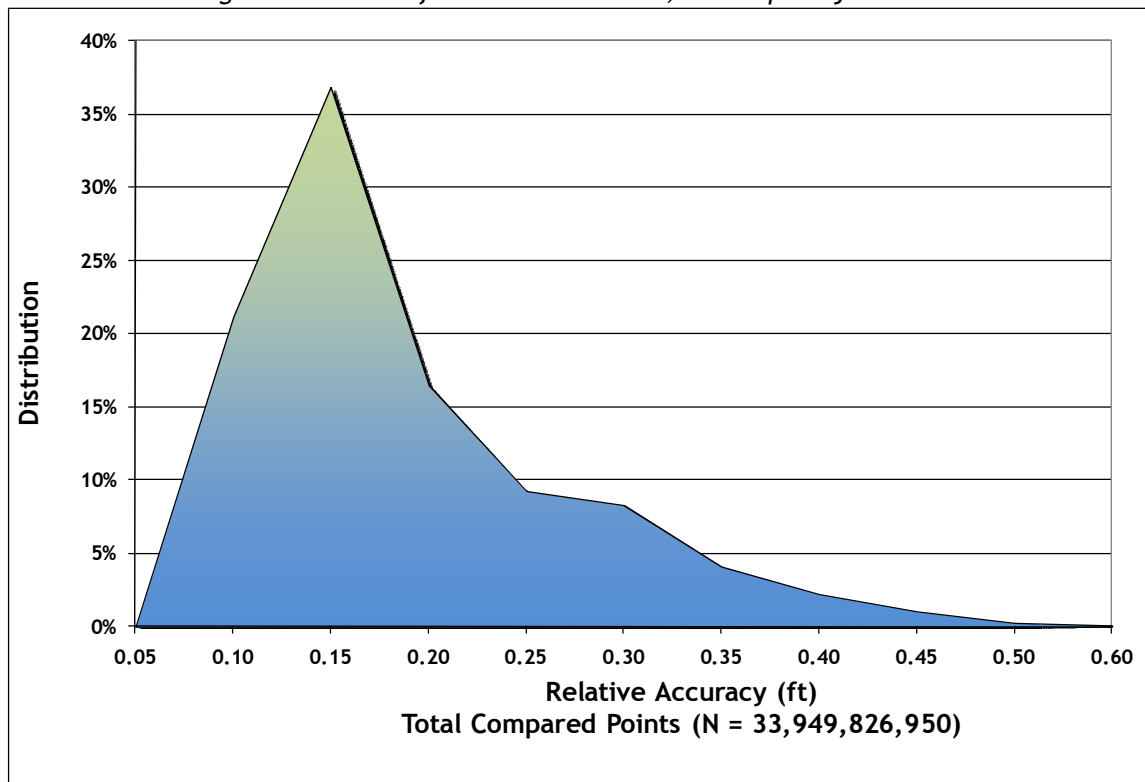


Figure 2.3. Percentage distribution of relative accuracies, non slope-adjusted.



## 2.2 Absolute Accuracy

Absolute accuracy compares known Real Time Kinematic (RTK) ground survey points to the closest laser point. For the Willamette Valley Phase I Study Area, 38,371 RTK points were collected for deliveries 2 - 13. Absolute accuracy for delivery area 14 is reported in the north coast, delivery areas 7 and 8, data report. Area covered by absolute accuracy is show in **Figure 2.4**.

**Table 2.1.** Absolute Accuracy - Deviation between laser points and RTK survey points.

Sample Size (n): 38,371	
Root Mean Square Error (RMSE): 0.13 ft (0.04 m)	
Standard Deviations	Deviations
1 sigma ( $\sigma$ ): 0.13 ft (0.04 m)	Minimum $\Delta z$ : -0.69 ft (-0.21 m)
2 sigma ( $\sigma$ ): 0.30 ft (0.09 m)	Maximum $\Delta z$ : 0.40 ft (0.12 m)
	Average $\Delta z$ : 0.11 ft (0.03 m)

**Figure 2.4.** Absolute Accuracy Covered Area.

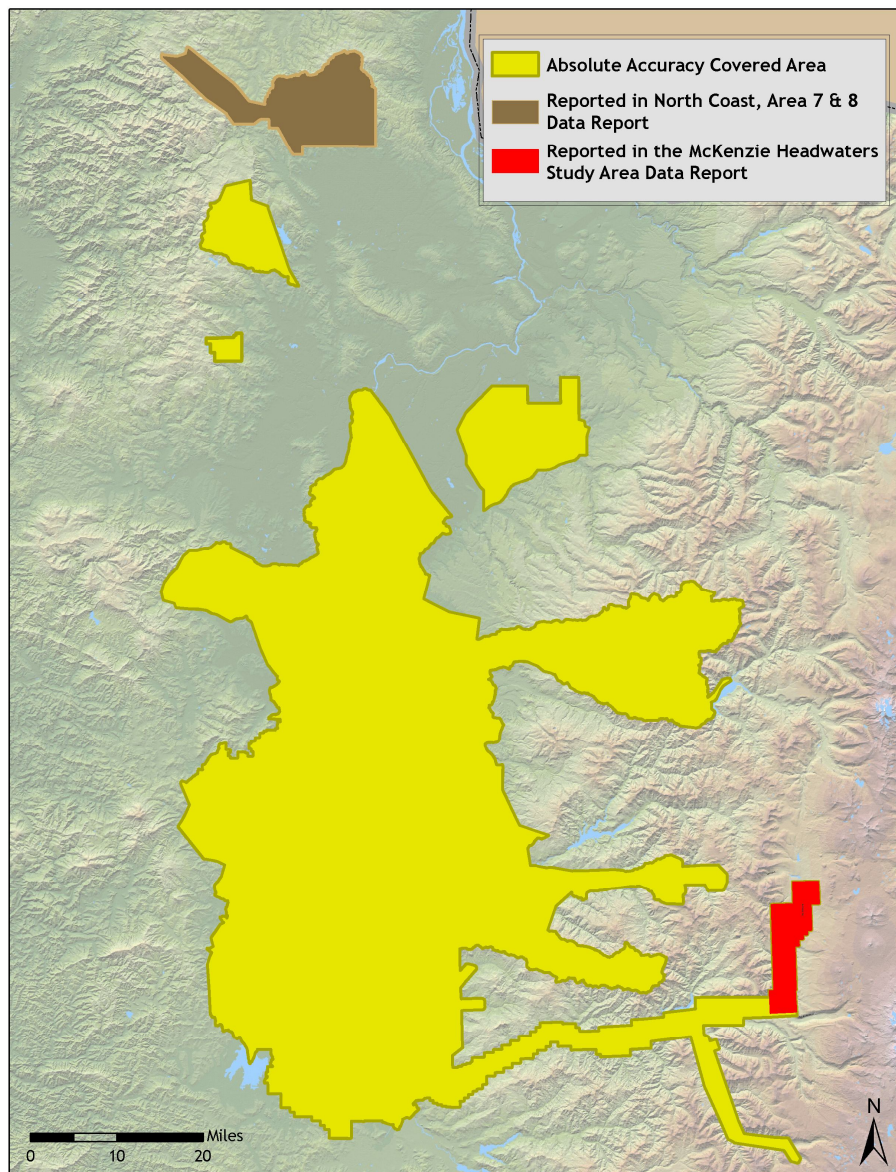




Figure 2.5. Willamette Valley Phase I Study area histogram statistics

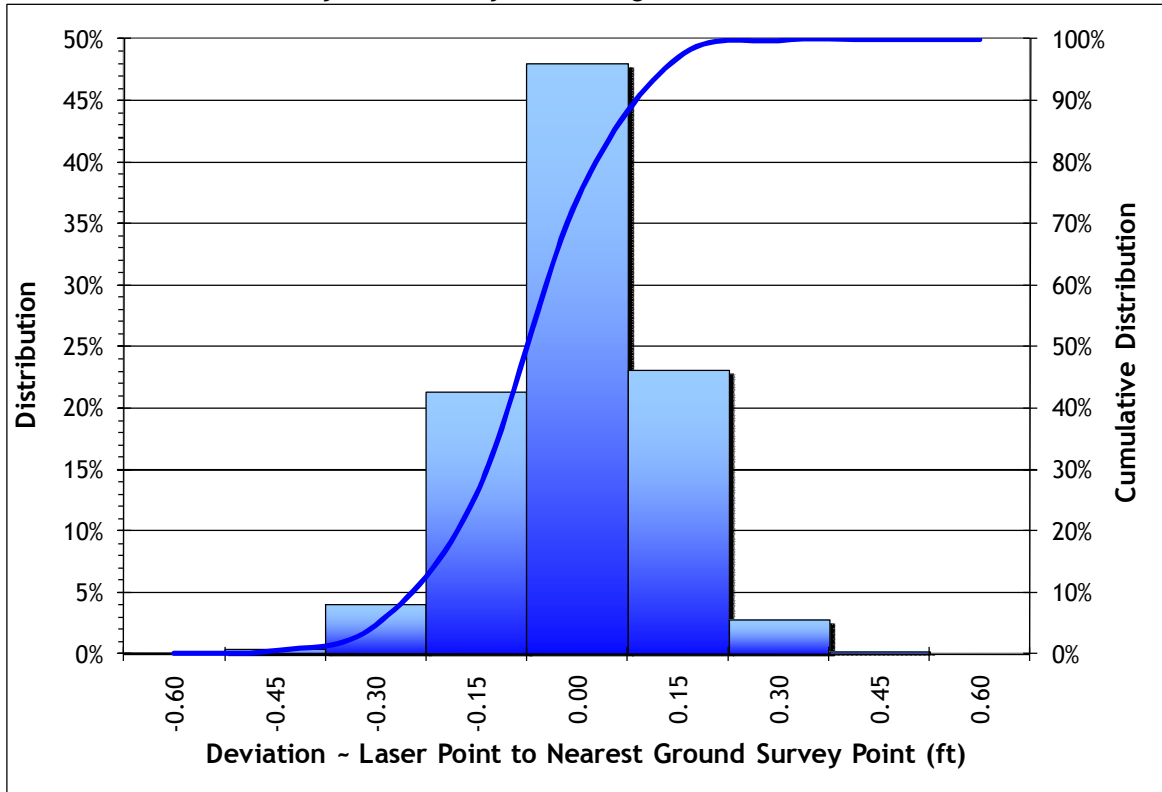
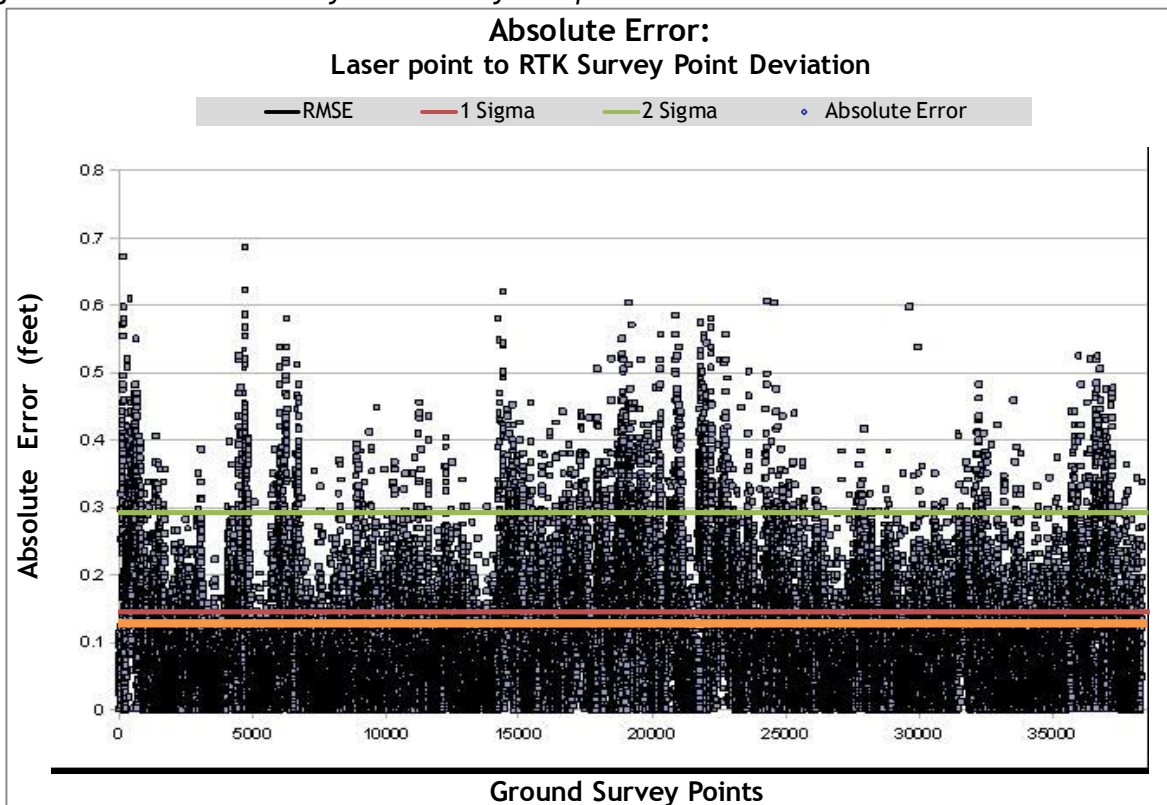


Figure 2.6. Willamette Valley Phase I study area point absolute deviation statistics.



### 3. Data Density/Resolution

#### 3.1 Density Statistics

Some types of surfaces (i.e., dense vegetation or water) may return fewer pulses than the laser originally emitted. Therefore, the delivered density can be less than the native density and vary according to distributions of terrain, land cover and water bodies. Density histograms and maps (Figures 3.1 - 3.4) have been calculated based on first return laser point density and ground-classified laser point density.

*Table 3.1. Average density statistics for Willamette Valley Phase I data.*

Average Pulse Density (per square ft)	Average Pulse Density (per square m)	Average Ground Density (per square ft)	Average Ground Density (per square m)
.76	8.14	.13	1.36

Data density statistics for area 14 are reported in the north coast, areas 7 and 8, data report.

*Figure 3.1. Histogram of first return laser point density for Willamette Valley Phase I data.*

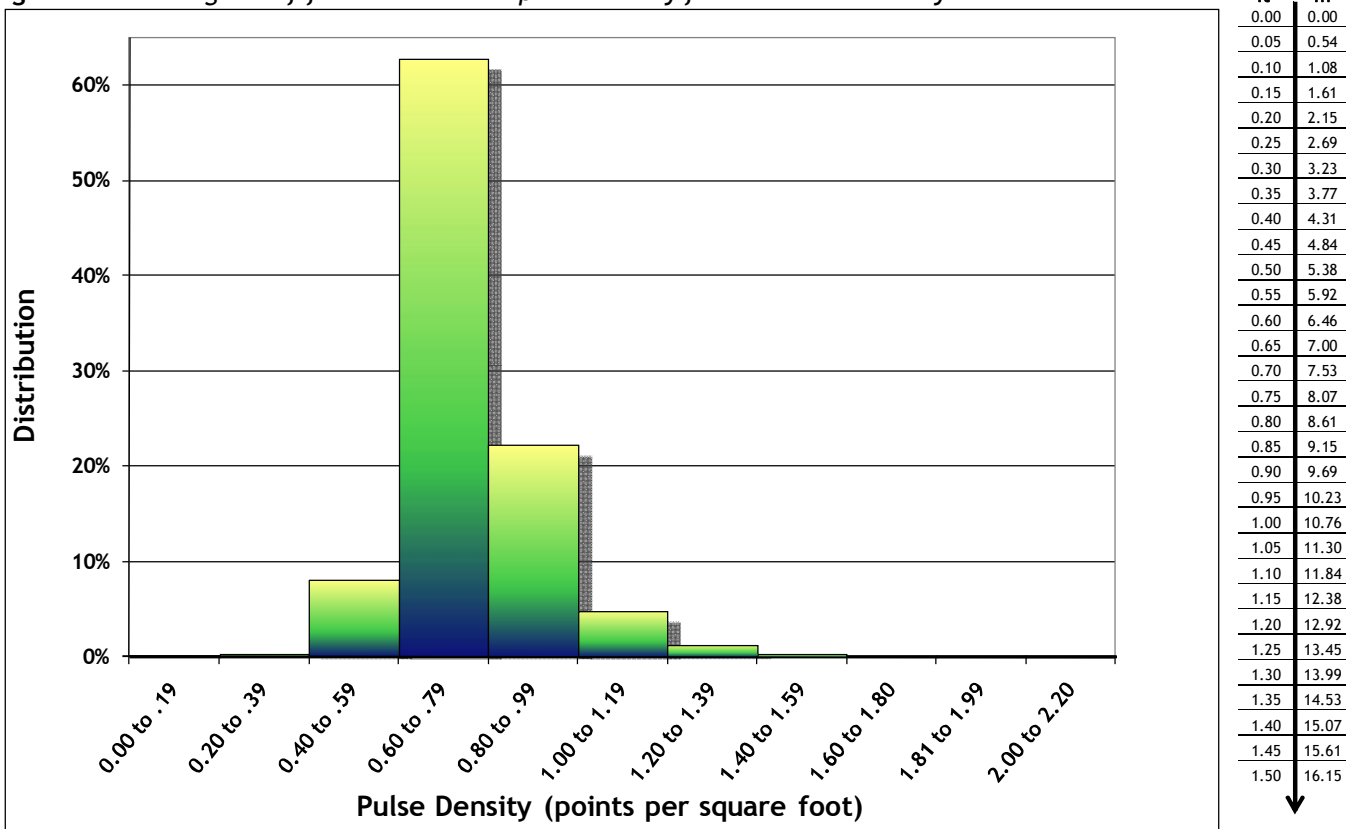
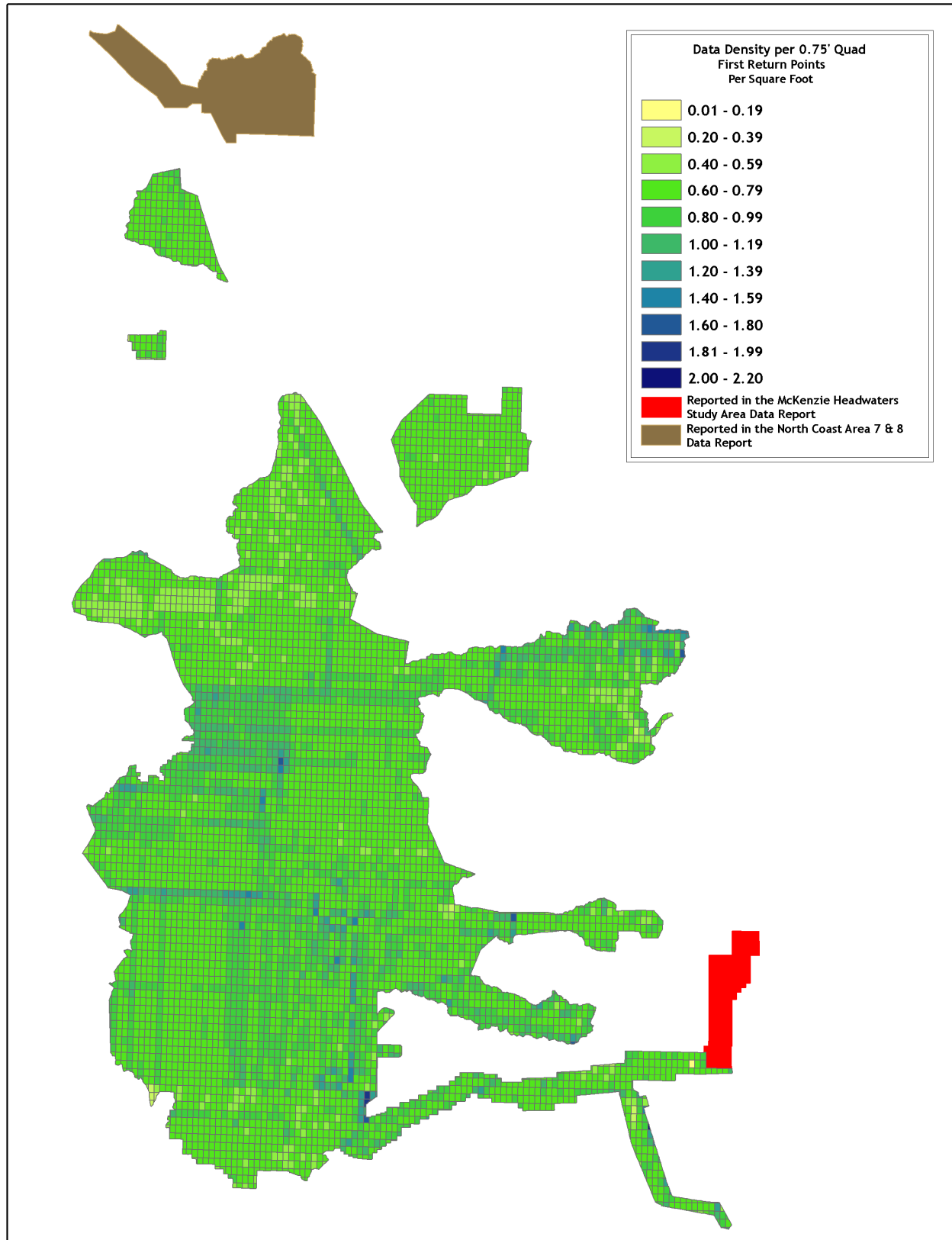




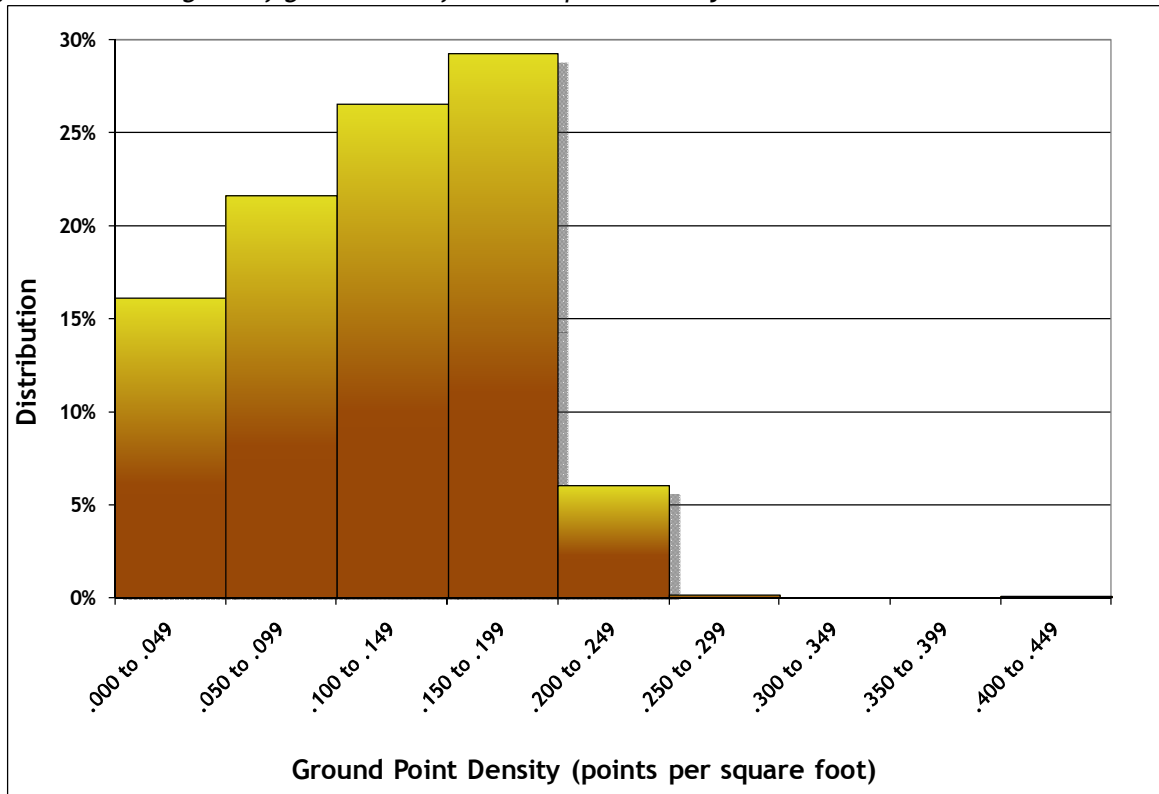
Figure 3.2. Image shows first return laser point per 0.75' USGS Quad.



Data density statistics for area 14 are reported in the north coast, areas 7 and 8, data report.

Ground classifications were derived from ground surface modeling. Supervised classifications were performed by reseeding of the ground model where it was determined that the ground model failed, usually under dense vegetation and/or at breaks in terrain, steep slopes and at bin boundaries.

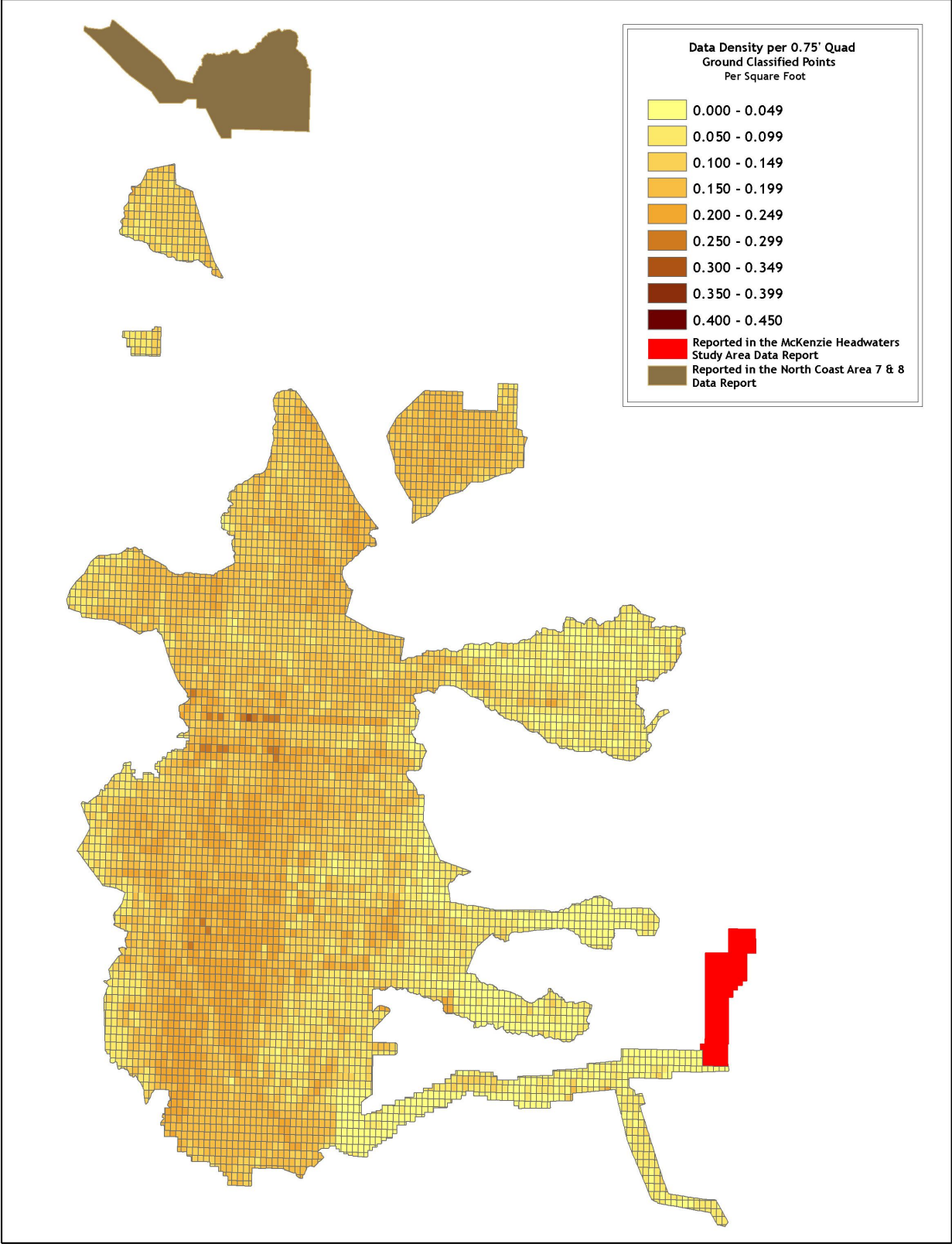
**Figure 3.3.** Histogram of ground-classified laser point density.



Pts ft <sup>2</sup>	Pts m <sup>2</sup>
0.00	0.00
0.05	0.54
0.10	1.08
0.15	1.61
0.20	2.15
0.25	2.69
0.30	3.23
0.35	3.77
0.40	4.31
0.45	4.84
0.50	5.38
0.55	5.92
0.60	6.46
0.65	7.00
0.70	7.53
0.75	8.07
0.80	8.61
0.85	9.15
0.90	9.69
0.95	10.23
1.00	10.76
1.05	11.30
1.10	11.84
1.15	12.38
1.20	12.92
1.25	13.45
1.30	13.99
1.35	14.53
1.40	15.07
1.45	15.61
1.50	16.15

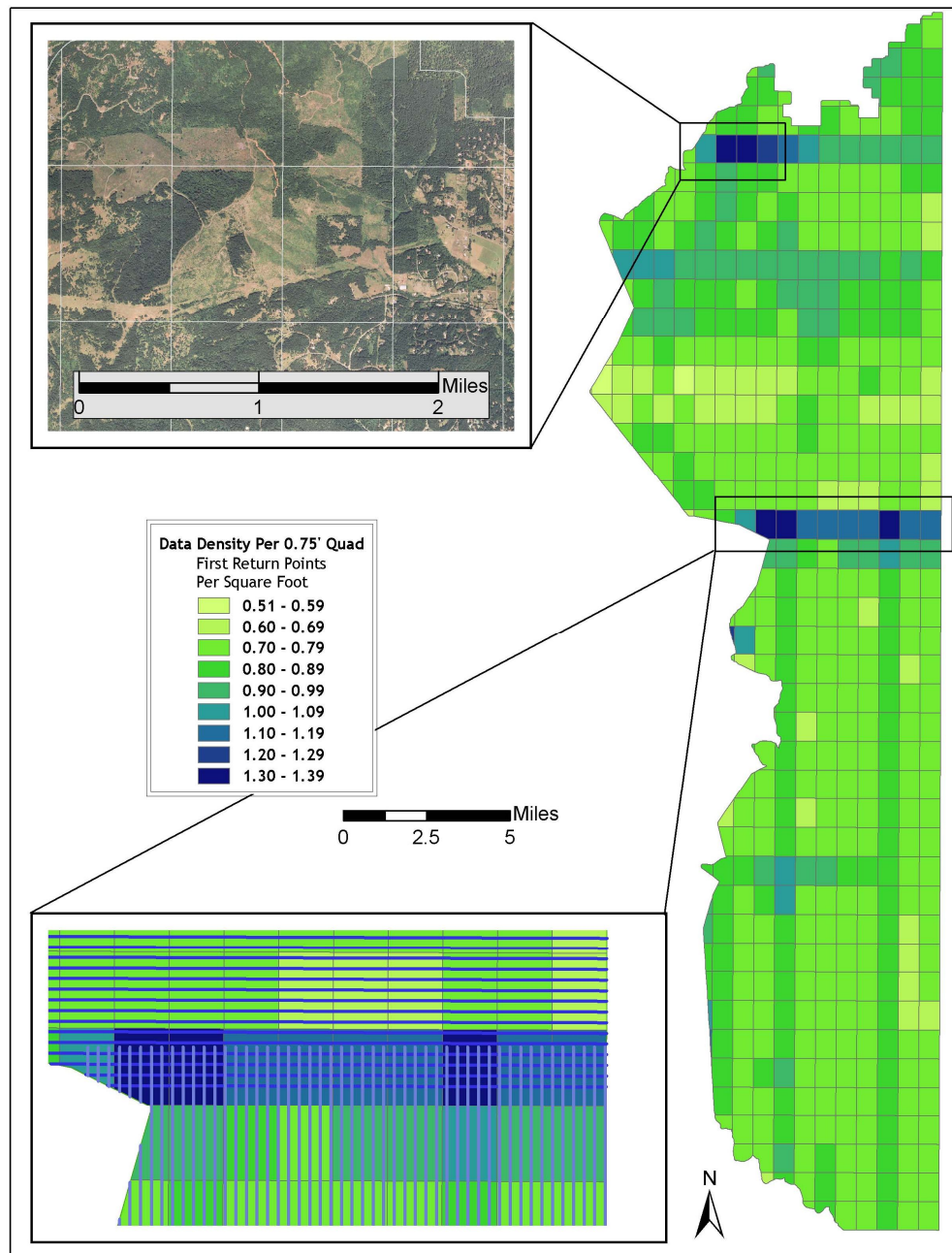


Figure 3.4. Ground-classified laser point density per 0.75' USGS Quad for data delivered to date.



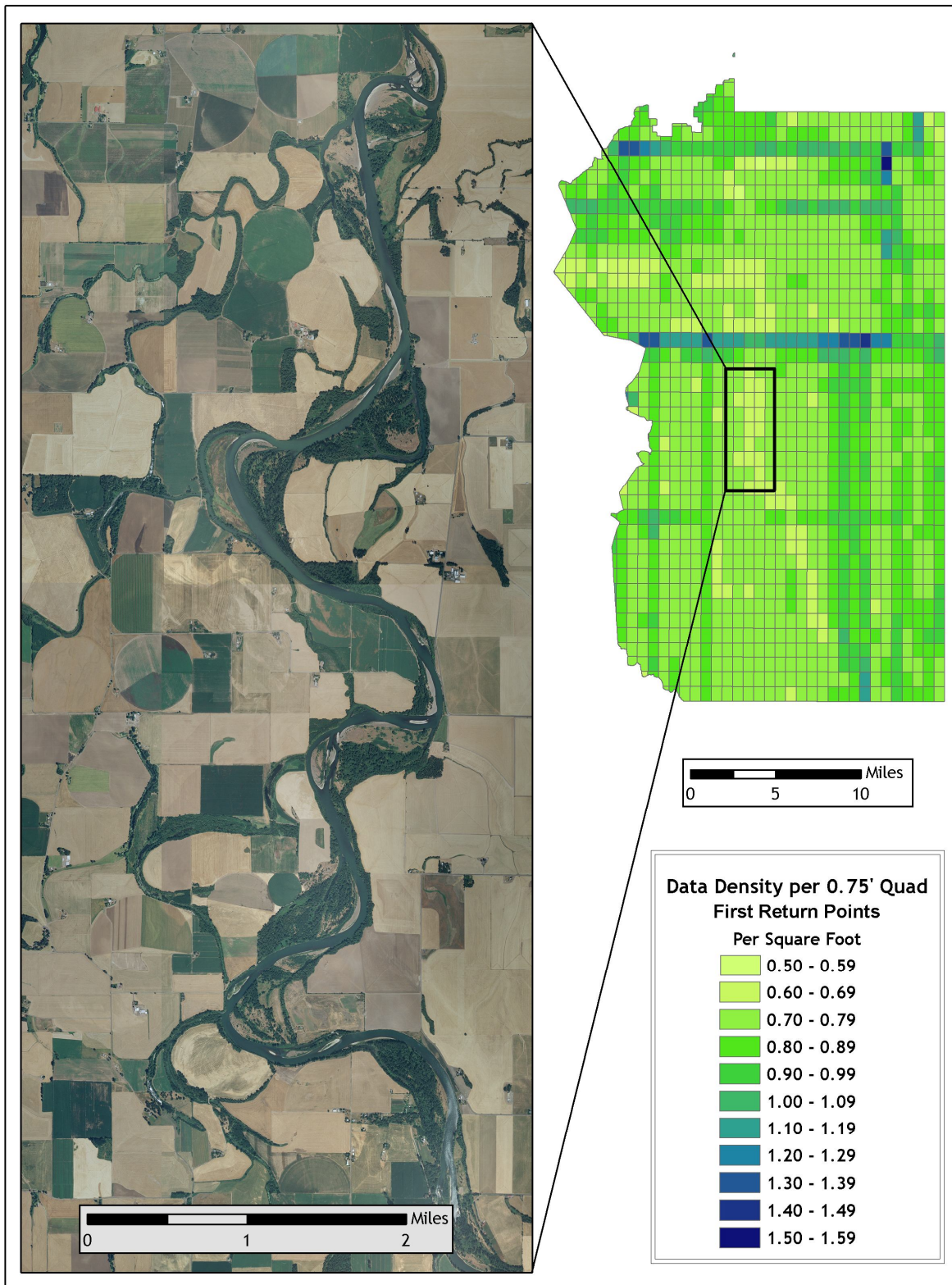
### 3.2 Selected Samples of Data Density/Resolution

**Figure 3.5.** *Quadrants containing high pulse density classified points include areas with overlapping flightlines.*

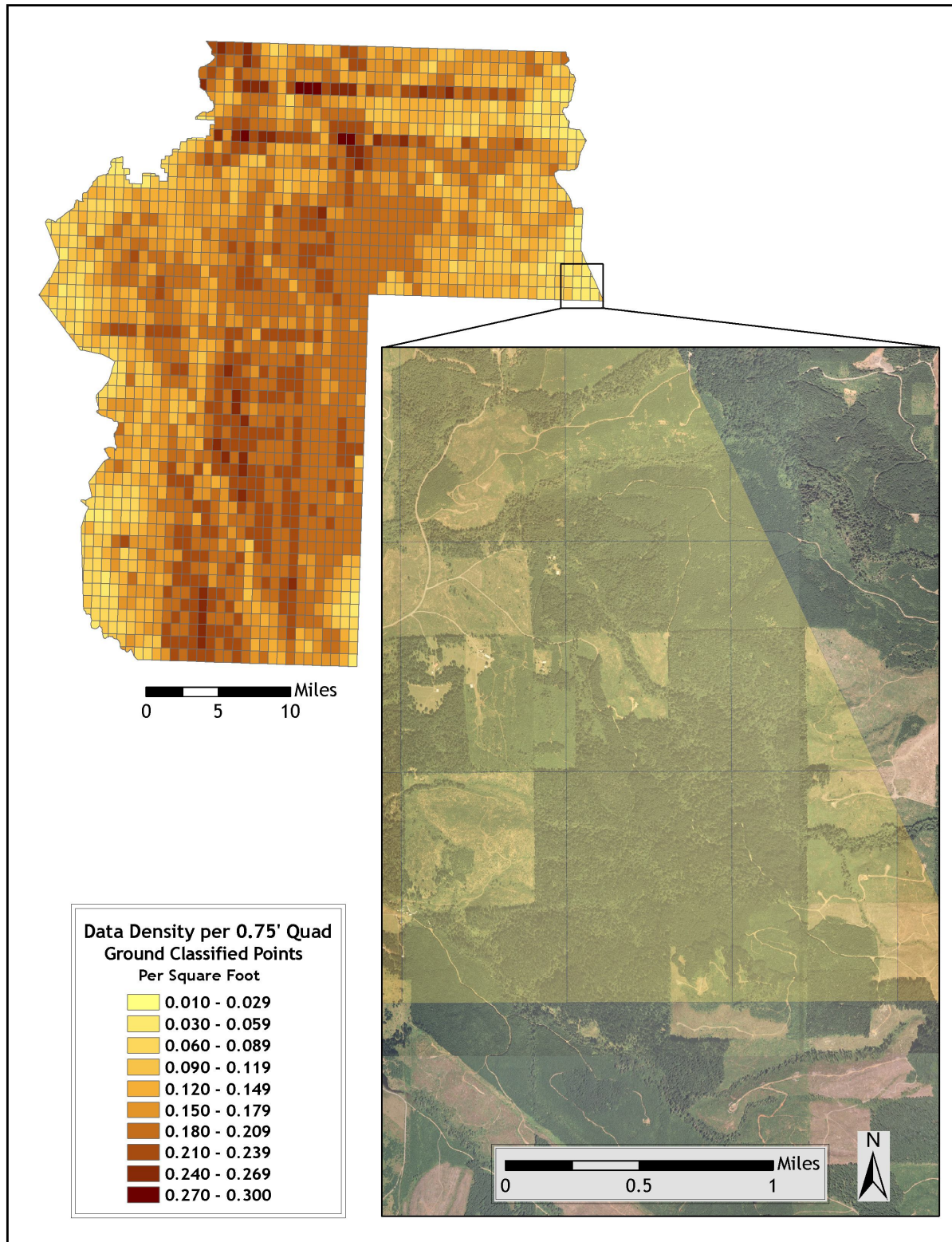




**Figure 3.6.** Quadrants containing low pulse density classified points include water bodies and shorelines.



**Figure 3.7.** Quadrants containing lower pulse density classified points include densely vegetated areas.





## 4. Selected Imagery

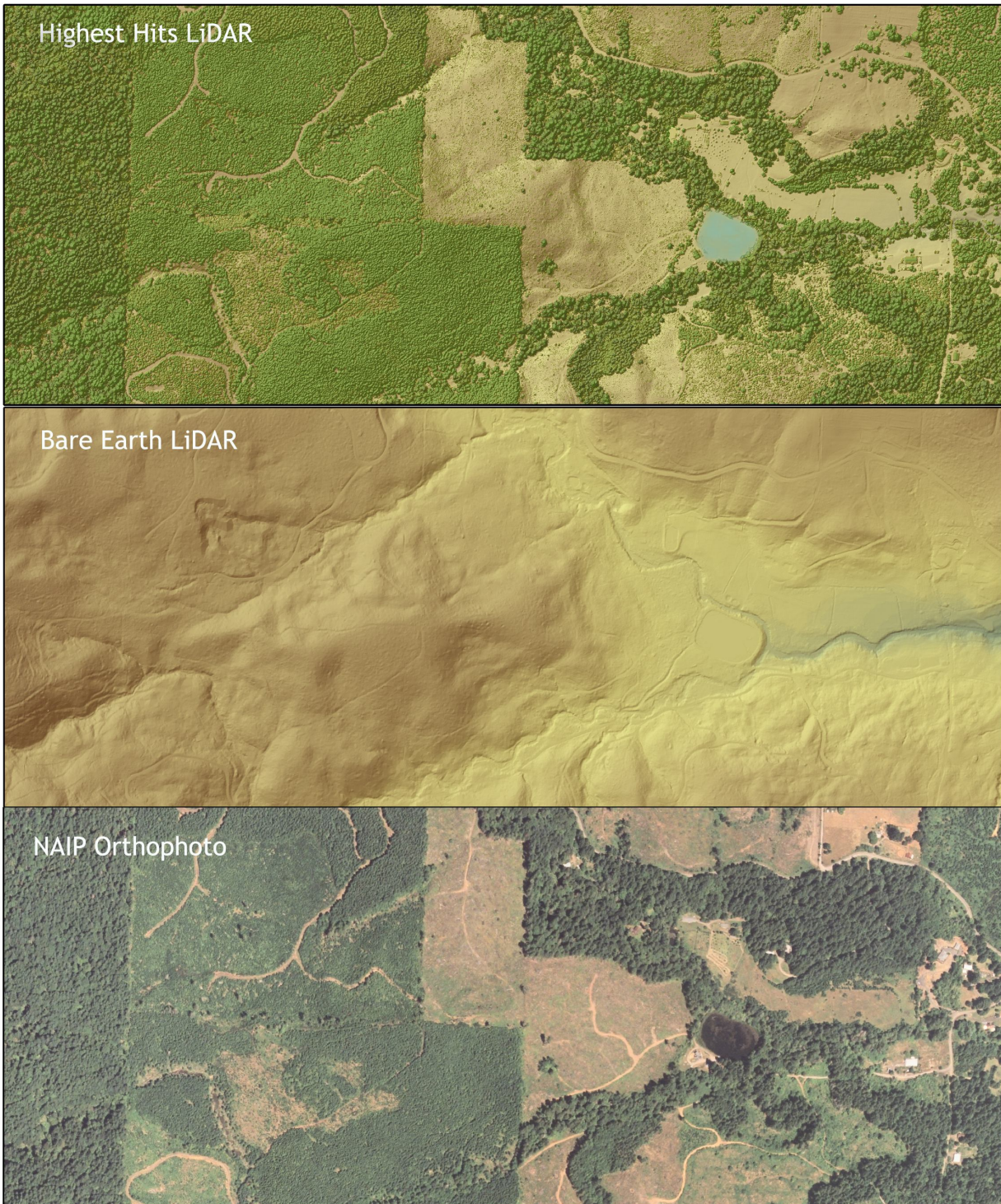
Example areas are presented to show sample imagery (see Figures 4.1-4.11).

**Figure 4.1.** Oxbow on the Santiam River south of the town of Jefferson, Oregon (Quadrangle 44123F1). The top image is derived from highest hit LiDAR, the center image is derived from bare earth LiDAR, and the bottom image is derived from NAIP Orthophoto.



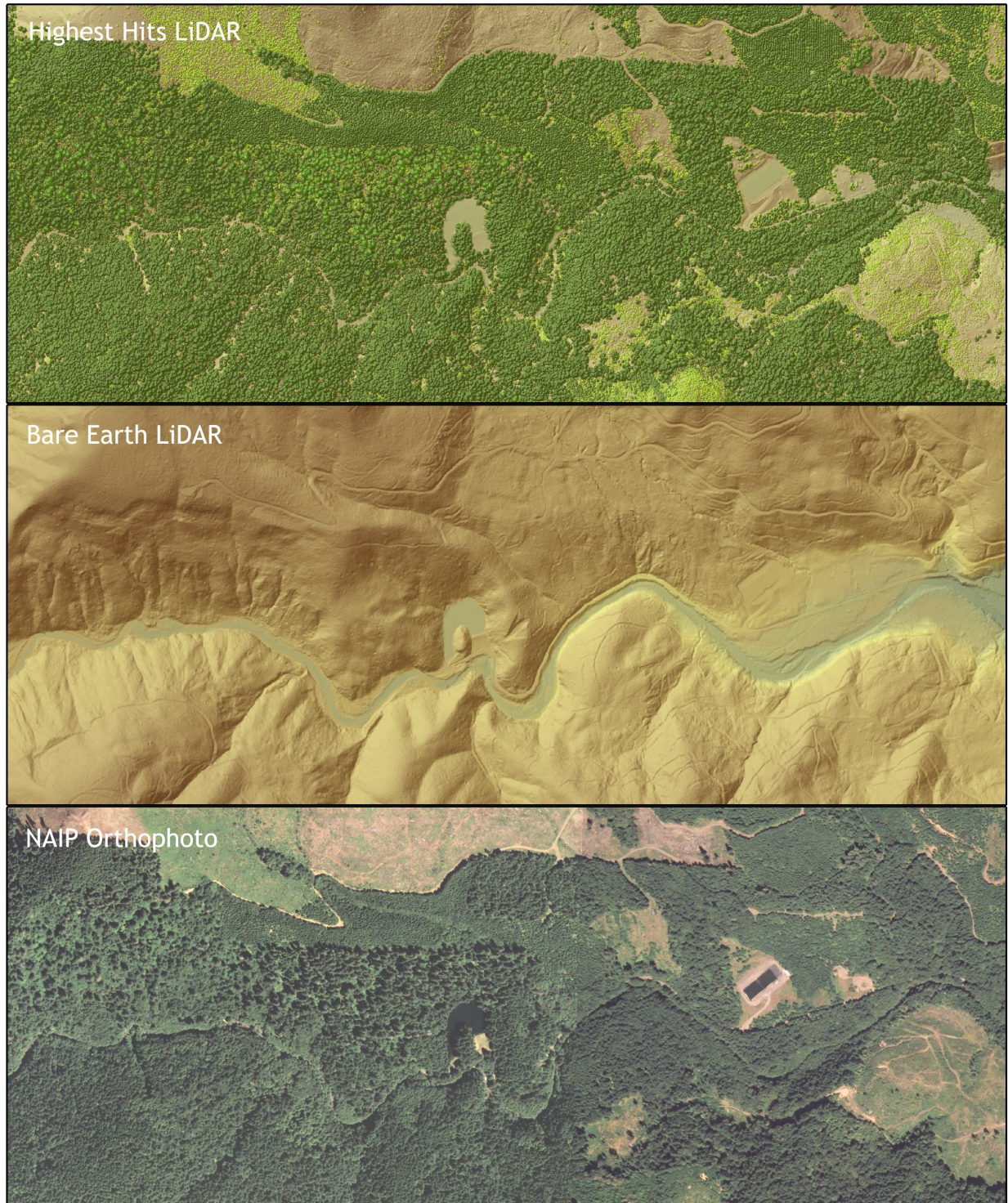


**Figure 4.2.** Von Reservoir located in the Siuslaw National Forest in Oregon (Quadrangle 45123C3). The top image is derived from highest hit LiDAR, the center image is derived from bare earth LiDAR, and the bottom image is derived from NAIP Orthophoto.



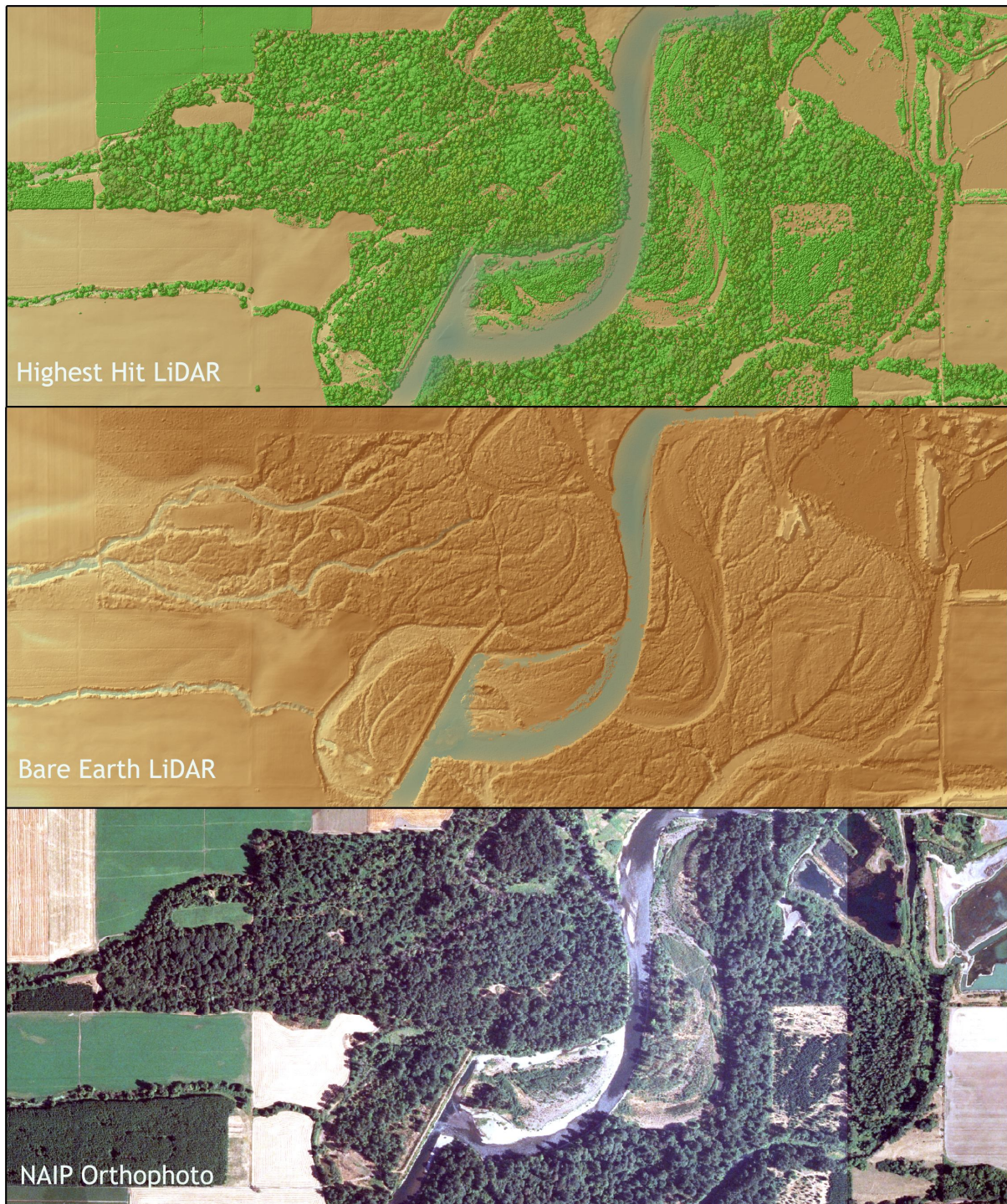


**Figure 4.3.** Hillsboro Reservoir located southwest of Forest Grove in Oregon (Quadrangle 45123D3). The top image is derived from highest hit LiDAR, the center image is derived from bare earth LiDAR, and the bottom image is derived from NAIP Orthophoto.



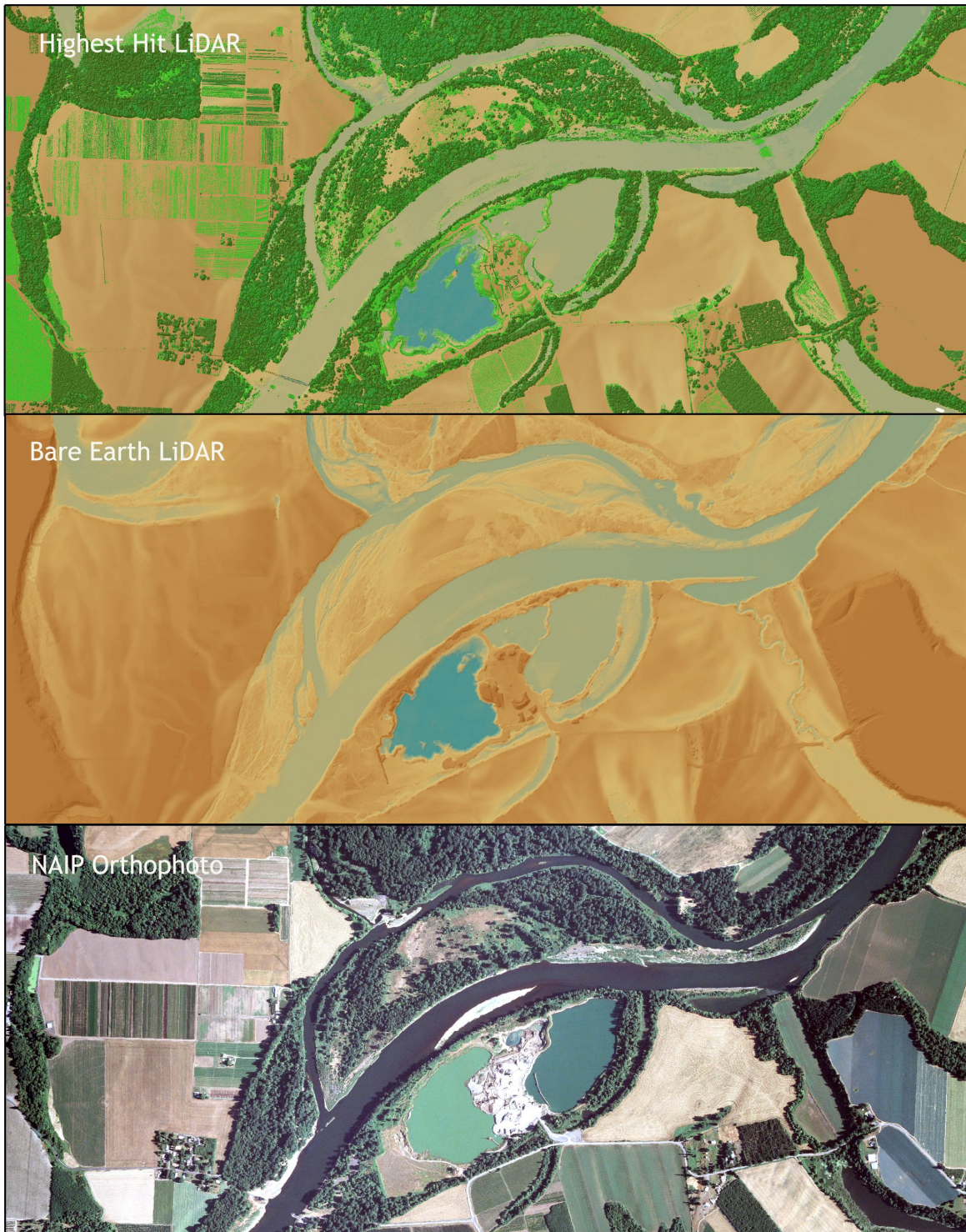


**Figure 4.4.** Santiam River south of the town of Stayton, Oregon (Quadrangle 44122G7). The top image is derived from highest hit LiDAR, the center image is derived from bare earth LiDAR, and the bottom image is derived from NAIP Orthophoto.





**Figure 4.5.** Stretch of the Willamette River north of Salem, Oregon (Quadrangle 45123A1). The top image is derived from highest hit LiDAR, the center image is derived from bare earth LiDAR, and the bottom image is derived from NAIP Orthophoto.





**Figure 4.6.** The Santiam River, west of Pleasant Valley (Quadrangle 44122D7). The top image is a NAIP Orthophoto, the center image is derived from highest hit LiDAR, and the bottom image is derived from bare earth LiDAR.



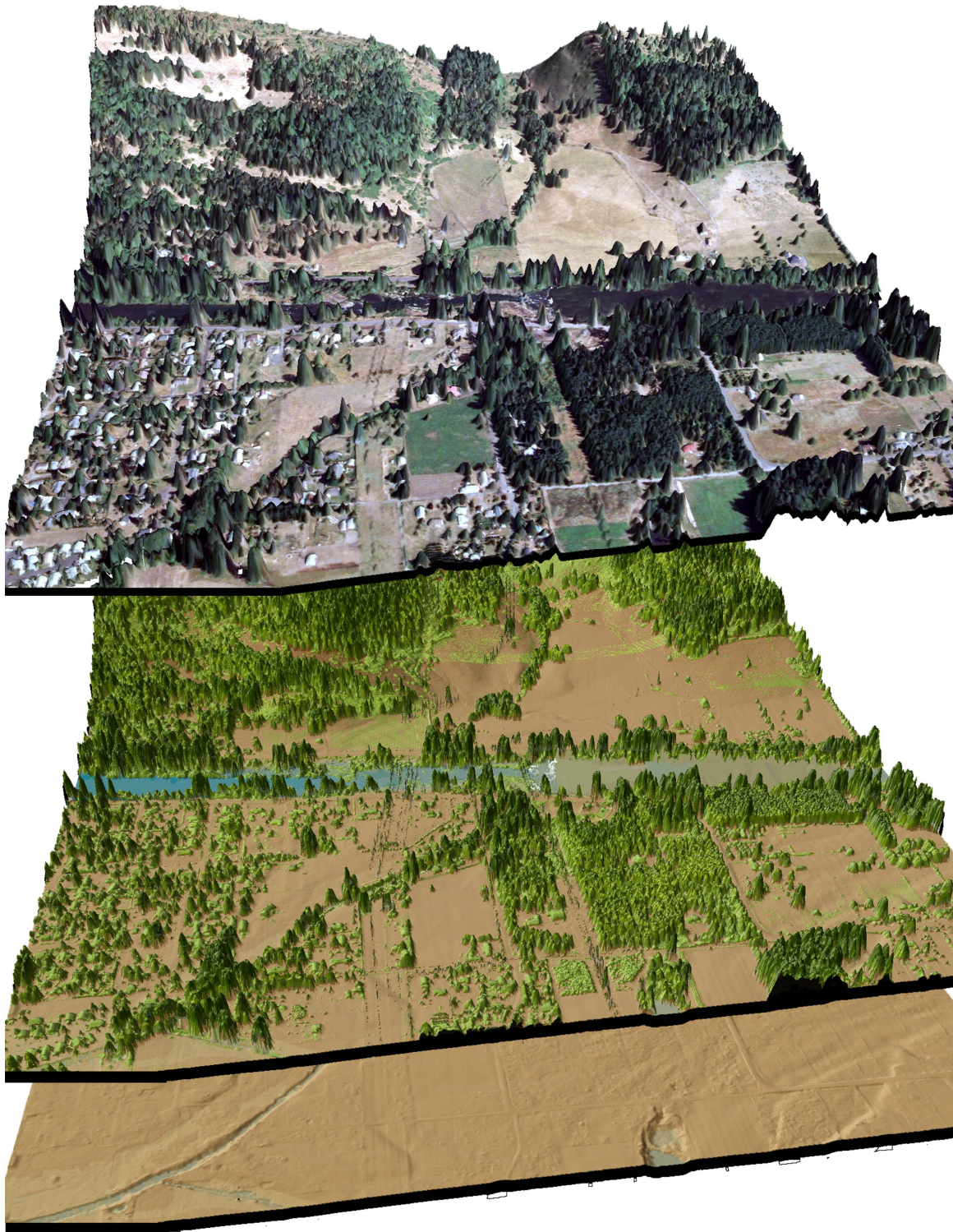


**Figure 4.7.** Plan view located in 7.5 Quad 44122A7 showing the Hwy 126 bridge crossing the McKenzie River just northeast of Cedar Flat. The top image is a NAIP Orthophoto, the center image is derived from highest hit LiDAR, and the bottom image is derived from bare earth LiDAR.



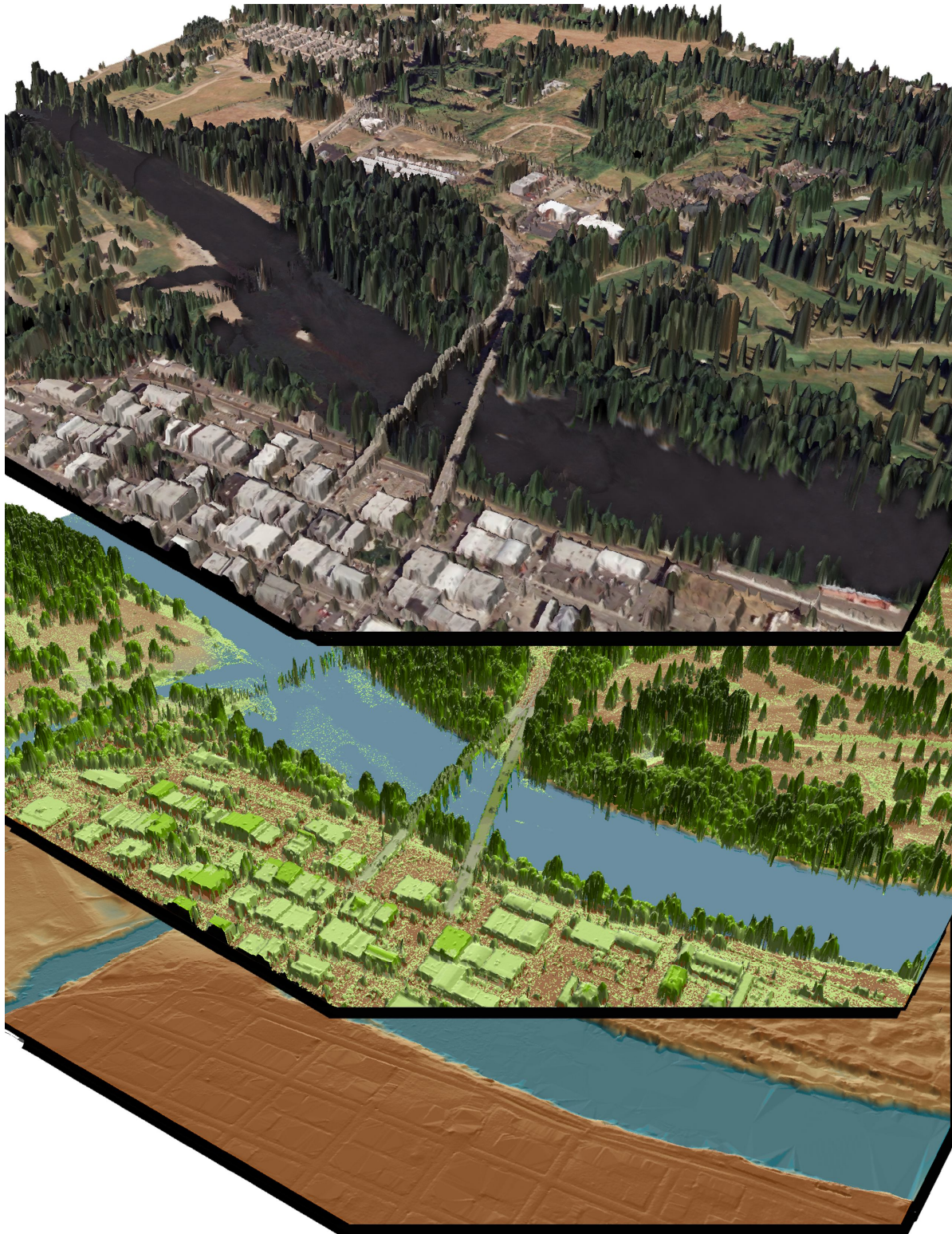


**Figure 4.8.** Diversion dam on the Santiam River in the town of Lebanon, Oregon (Quadrangle 44122E8). The top image is a NAIP Orthophoto, the center image is derived from highest hit LiDAR, and the bottom image is derived from bare earth LiDAR.



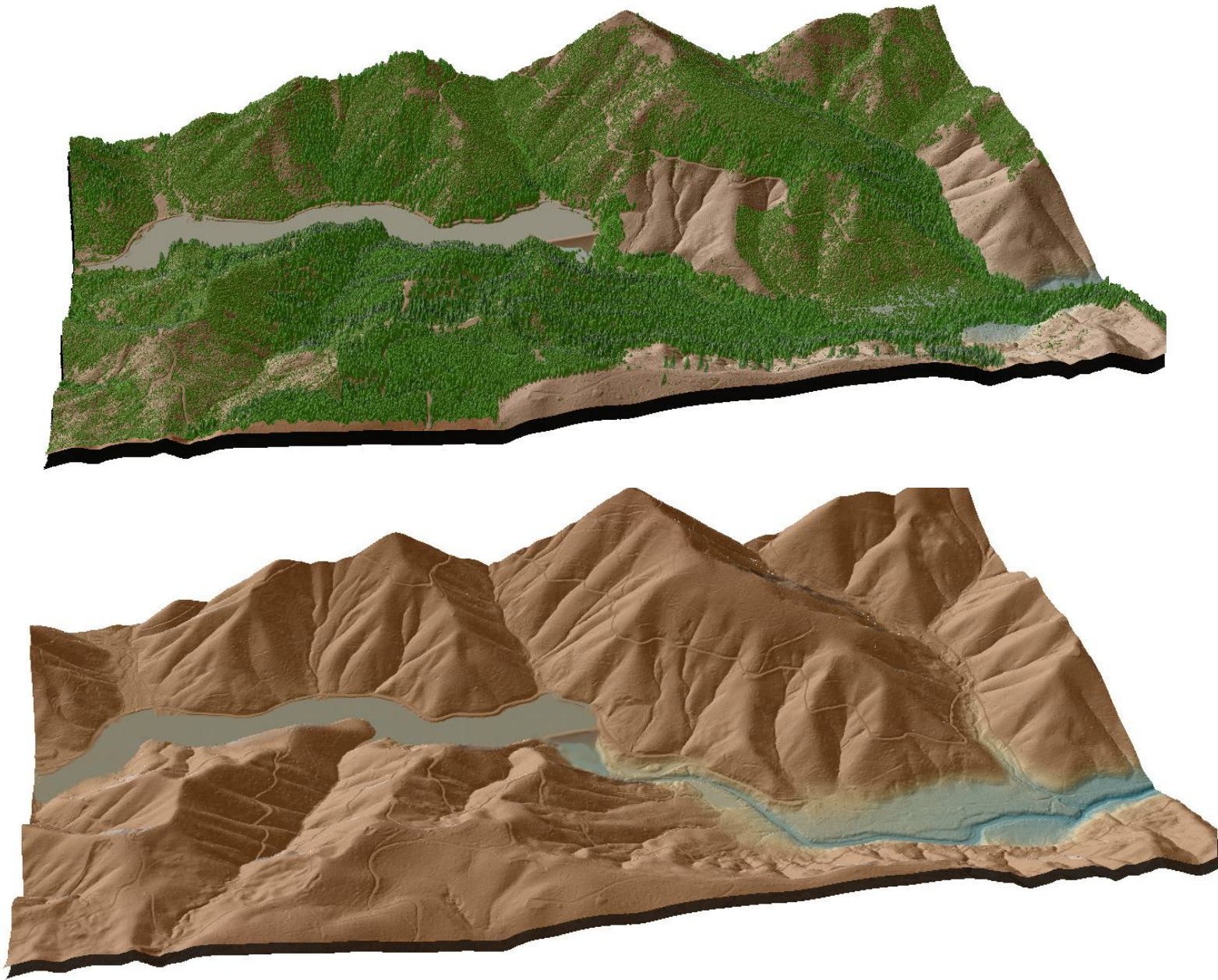


**Figure 4.9.** Highway 20 bridge over Willamette River in Albany, Oregon (Quadrangle 44123F1). The top image is a NAIP Orthophoto, the center image is derived from highest hit LiDAR, and the bottom image is derived from bare earth LiDAR.





**Figure 4.10.** Aaron Mercer Reservoir located west of Salem, Oregon(Quadrangle 44123H4). The top image is derived from highest hits LiDAR, the bottom image is derived from bare earth LiDAR.





**Figure 4.11.** Terwilliger Hotsprings located near east of the Cougar Reservoir. (Quadrangle 44122A2). The top image is derived from highest hits LiDAR, the bottom image is derived from bare earth LiDAR.

